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National Bureau
of Standards

Computer Science and Technology

NBS Special Publication 500-110

Microcomputers: Introduction to Features and Uses

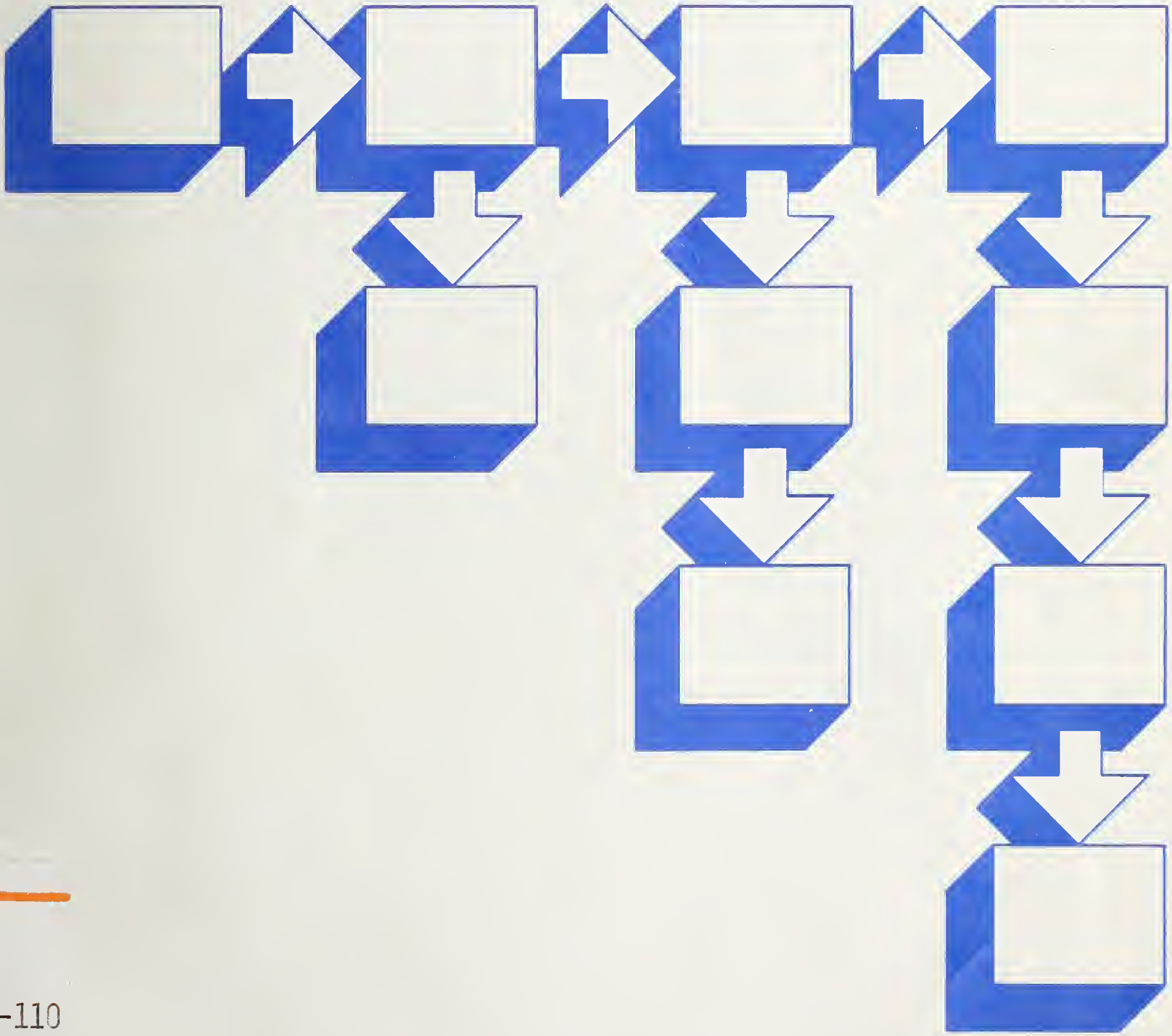

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TABLE OF CONTENTS

TABLE OF CONTENTS

(continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES

(continued)

EXECUTIVE SUMMARY

This report describes microcomputers, their uses, and costs. Its objectives are to introduce microcomputers to readers with some knowledge of computing but little or no background in microcomputers and to identify important issues associated with their implementation in Government agencies.

Because of their low cost, microcomputers provide an opportunity to automate activities in ways that had previously not been achievable. In addition, they can provide a lower cost alternative to executing similar programs on larger systems while providing users with more control over the computer. Microcomputers pose a particular management challenge because of their dispersion in large numbers throughout Federal agencies. The resulting problems of data integrity, control, and security can be minimized if they are addressed early.

The computing function has two parts: hardware and software. Hardware is a term which denotes the physical units comprising the microcomputer, i.e. the electronics, cabinet, keyboards, displays, and printers. The economics of development and manufacture dictate that hardware be designed to serve a wide range of applications. The resultant benefit to users is the ability to purchase a useful computer at a low cost. However, this generality results in a system which must be subsequently adapted to perform useful functions.

Software refers to computer programs. They consist of a list of instructions that adapts the computer to a specific application by causing the hardware to act in a certain manner. Software performs three major functions: (1) supervising the operation of the hardware, (2) performing computation tasks for end users, and (3) aiding computer users and programmers. The first function is handled by a set of computer programs which are collectively known as <u>systems software</u>. The second function is handled by <u>application programs</u>, and programs which handle the third function are called <u>software tools</u> or <u>software development aids</u> .

This report classifies Federal microcomputer users as follows:

<u>Clerical</u>

Clerical users include typists, junior secretaries, and data entry personnel. Most clerical uses of microcomputers involve data input (either numbers or text) formatting, or transcribing. Document preparation and administrative data entry are the most common applications of microcomputers.

<u>Administrative</u>

Administrative users of microcomputers include managers and other Federal workers whose primary responsibility is related to administrative tasks. Administrative uses of microcomputers include accounting, budgeting and planning.

Professional

Professional users include natural and social scientists, educators, legal workers, and others working in professional fields. Their uses of microcomputers include data analysis (primarily statistics) and document preparation.

Technical

Technical users include programmers. engineers, and researchers who perform their own computer-based system design and programming. The primary distinction between technical and professional users is the extent to which they perform their own programming.

The following table lists some user related characteristics that affect microcomputer usage:

CHARACTERISTIC	CLERICAL	ADMINISTRATIVE	PROFESSIONAL	TECHNICAL
Scope of computer related tasks	Specia-lized	Broad	Broad	Broad
Necessity of computer-based systems for job	High	Low	Low	Variable
Computer Background	Limited	Limited	Variable	Substantial
Relative amount of system usage	High	Low	Low	High
Tolerance for malfunctions, problems	Low	Low	Low	Variable
Availability of personnel for extensive training	High	Low	Low	Low
Need for subsequent support	High	High	Variable	Low
Need for technical information	Low	Low	Low	High

Application software transforms a general purpose microcomputer into a system for performing useful tasks such as writing a letter or preparing a budget. The following table shows the most common types of microcomputer application software:

APPLICATION SOFTWARE TYPE	PURPOSE
WORD PROCESSING	Creating, editing, and printing documents
DATA MANAGEMENT	Organizing, storing, and retrieving data
SPREAD SHEET PROCESSORS	Performing calculations and formatting for tabular reports (e.g. budget forecasts)
GRAPHICS	Presentation of data graphs and preparation of diagrams and illustrations
COMMUNICATION	Data transfer to and from other systems
SPECIALIZED SOFTWARE	Specialized computation tasks associated with various job functions (e.g. accounting, statistics)

These applications can work independently, they can also be integrated through the use of common file structures, integrated packages, multitasking operating systems, or application environments.

In addition to these applications, specialized software exists to perform tasks such as project management, capital assets management, or electronic design. In cases where no suitable specialized programs meet the needs of end users, custom programming is necessary. Users should first consider a data base management system or spread sheet analyzer before embarking on a software development effort in a more traditional computer language.

Although the cost of the microcomputer hardware and software is relatively low, the cost of effective implementation in a large organization can be much higher. The system costs start at the time the procurement is initiated and continue throughout its life. Major cost components include hardware, software, procurement, site preparation, installation and implementation, training, supplies, maintenance, and communications.

Microcomputers create two types of risks: technical and organizational. Technical risks are related to the inability of the system to function according to expectations -- i.e. total failures or inadequate implementations. Although installation of larger systems also entails some technical risks, microcomputers are unique because they are installed in settings where expert support is not always readily available.

Organizational risks arise because of the problems in implementing and managing microcomputers in large organizations. Even if microcomputer installations are satisfactory from the individual user's point of view, they can pose a risk to the organization as a whole because of the difficulty of controlling such systems. In addition, there are concerns over mastering the new technology and the change in the nature of the centralized computing function.

Preventing the problems given above requires a recognition of the risks and explicit actions to reduce or avoid them. Among the actions that an agency can take are the institution of microcomputer policies, support provisions, maintenance planning, and development ot a training program.

Those considering implementation of microcomputers in their agencies should consider the following points:

Microcomputer technology is advancing at a rapid rate and new products are constantly being introduced.

Effective utilization of microcomputers requires continuous support.

Successful implementation of microcomputers requires consideration of a broad range of technological, organizational, ergonomic, and psychological issues.

The primary focus of control and responsibility for microcomputers shifts from a centralized data processing department (which traditionally controls larger installations) to individual users.

ABSTRACT

This document is an introduction to microcomputers and their uses in the Federal government. Basic concepts in microcomputers are discussed, and their uses by clerical, administrative, professional, and technical Federal personnel are described. The motivations, costs, and risks of microcomputer use are identified, and recommendations for successful implementations are provided. Appendices contain a glossary and annotated bibliography.

KEY WORDS: microcomputer hardware; microcomputer management issues; microcomputer software; microcomputer technical considerations; microcomputers.

CHAPTER 1 - INTRODUCTION

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST), acting in response to its Brooks Act (Public Law 89-306) charter, promotes the cost effective selection, acquisition, and utilization of automated data processing (ADP) resources within Federal agencies. ICST efforts include research in computer science and technology, direct technical assistance, and the development of Federal standards for data processing equipment, practices, and software.

This report describes microcomputers, their uses, and costs. Its objectives are to introduce microcomputers to readers with a limited background in this field and to identify issues related to their implementation in Government agencies.

1.1. MOTIVATION

Figure 1-1 [YOUN82] demonstrates the large and growing importance of microcomputers. Because of their low cost, microcomputers provide an opportunity to automate activities in ways that had previously not been achievable. Some tasks that they perform had previously been assigned to large computer installations and are being shifted to microcomputers because of economic reasons or because the user prefers more control over computer resources. It is therefore not surprising that Federal agencies are procuring microcomputers in sizable quantities. During an arbitrarily selected month in 1982, they accounted for 45% of the ADP procurement announcements in the *Commerce Business Daily*, and an additional 27% of the procurements were for minicomputers whose performance was in the range of microcomputers.

Because of their low cost, microcomputers can be procured and installed in most Federal agencies with much less review and planning than is required for the purchases of larger computers. However, these installations are susceptible to a number of problems including:

- Limited computer experience among end users
- A lower level of experience and capability among microcomputer sales personnel than among minicomputer and mainframe sales teams
- Difficulty of providing pre- and post-installation support
- Rapidly changing technology
- Incompatibilities among systems in a single organization

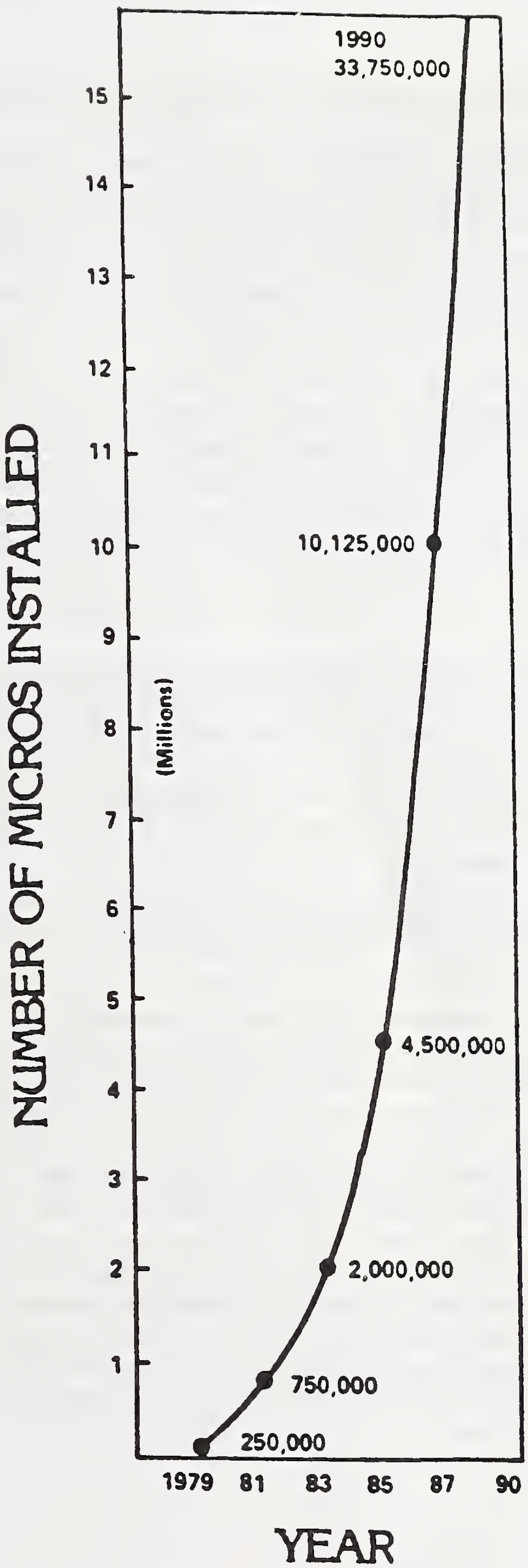

Figure 1-1. Projected Growth of Microcomputer Installations [YOUN82].

1.2. FEDERAL REGULATIONS AFFECTING MICROCOMPUTER PROCUREMENT AND USE

The foundation of Federal ADP procurement regulations is the Brooks Act in which the Congress recognized the need for Government-wide coordination to ensure the economic acquisition of computers and related items. The Brooks Act requires that Federal agencies wishing to acquire ADP equipment submit a purchase request to the General Services Administration (GSA) for review and authorization. The regulations also call for the consolidation of agency procurements in order to achieve quantity discounts. Above a certain threshold ($500,000 was the threshold in August, 1983; it is raised as necessary), the GSA directly participates in the acquisition process. However, lower cost systems are covered by GSA's Federal Supply Schedule Program in which contracts are negotiated with commercial firms to provide supplies and services at stated prices for a given period of time. A provision in this schedule known as the Maximum Ordering Limitation (MOL - $50,000 in 1983) authorizes Federal agencies to procure systems directly from vendors up to the MOL without further negotiations.

Because the Brooks Act did not anticipate the advent of computer systems costing under $5000, it did not provide a framework for microcomputer procurement. Individual agencies have established policies that range from <u>laissez faire</u> to specification of a named system with extensive justification and approval required for exceptions. Moreover, any degree of control can be circumvented by disguising microcomputers as laboratory equipment, training devices, or office machines.

Although microcomputer procurement has evaded centralized control, microcomputer usage has not. The Privacy Act (1974), the Tax Reform Act (1976), and the Fair Credit Reporting Act (1974) addressed concerns on the accuracy, integrity, accountability, and accessibility of information held by the Federal government in all computers — microcomputers are not exempt. The Paperwork Reduction Act (1980) dealt with these concerns and also required justification for the relevance of the information gathered and the efficient use of the technology. OMB Circular A71 (1976) addressed concerns on the misuse and abuse of Government computer systems, and OMB Circular A123 (1983) specifically addresses internal controls in Government financial systems. The overall intention of these laws and regulations is to control how Government information -- particularly that affecting individuals and private organizations -- is gathered, stored, and processed. Microcomputers pose a particular management challenge because of their dispersion in large numbers throughout Federal agencies. The resulting problems of data integrity, control, and security can be minimized if they are addressed during the computer procurement stage.

1.3. CONTENTS OF THIS REPORT

This report introduces microcomputers and discusses their implementation and use in Federal agencies. The following topics are covered:

Microcomputer Hardware and System Software

Chapter 2 describes microcomputer hardware and system software.

Microcomputer Users

Chapter 3 defines a classification of Federal users consisting of four categories: clerical, administrative, professional, and technical. The chapter describes distinguishing characteristics of each classification and relates them to desirable microcomputer features and capabilities.

Microcomputer Applications

Chapter 4 discusses the use of microcomputers by the four user classes defined in Chapter 3. It also covers issues concerned with the use of specialized application software and integrated packages.

Management Issues of Microcomputers

Chapter 5 identifyies management and usage issues of microcomputers. It also includes a discussion of the types of microcomputer systems currently available and the appropriate uses.

Glossary of Terms

Appendix A contains a glossary of terms related to microcomputing.

Annotated Bibliography

Appendix B contains a list of books and articles written at a nontechnical level on various subjects discussed in this report.

Much of the information of these chapters is presented in tabular form. This format also shows the relationship among issues and facilitates the identification of important points. Related Special Reports have been prepared on the following topics: programming of microcomputer systems [NBS83a], microcomputer selection [NBS83b], and selecting microcomputers for administrative and managerial users [NBS83c].

1.4. DISCLAIMER AND TRADEMARK IDENTIFICATIONS

Because of the nature of this report, it is necessary to mention some vendor names and commercial products. The presence or absence of a particular trade name does not imply criticism or endorsement by the National Bureau of Standards, nor does it imply that the products identified are necessarily the best available for the purpose.

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Finally, the authors wish to emphasize that the technology is rapidly changing. When this study was initiated in May of 1982, 8-bit computers still dominated the marketplace. By the time it was completed, microcomputers capable of executing mainframe software were available. However, issues related to the nature of the end user communities, the peculiar problems and possibilities of the highly interactive computing, and the requirements for computer applications appear to be less volatile. Emphasis has been placed on these latter issues, but discussions related to hardware and operating systems are of necessity more temporal.

CHAPTER 2 - OVERVIEW OF MICROCOMPUTERS

This chapter discusses the function of microcomputer hardware and software components. Section 2.1 introduces the concepts of hardware and software. Section 2.2 discusses microcomputer hardware, section 2.3 describes microcomputer systems software, and section 2.4 introduces programming languages. Section 2.5 discusses microcomputer communication, and section 2.6 concludes this chapter with a description of types of microcomputer systems.

2.1. WHAT IS A MICROCOMPUTER?

A microcomputer is a small and inexpensive computer. To a computer designer, a microcomputer is a system centered around a microprocessor and associated circuitry (see section 2.2.9). To computer programmers, a microcomputer is a new type of system for executing programs. Information resources managers may view microcomputers as the means by which the data processing function is restructured. To users, microcomputers represent an accessible and convenient form of computing. Perhaps the only common element in each of these perspectives is that microcomputers are the most significant development in data processing to emerge from the late 1970s.

The computing function has two parts: hardware and software. Hardware denotes the physical units comprising the microcomputer, i.e. the electronics, cabinet, keyboards, displays, and printers. The economics of development and manufacture dictate that hardware be designed to serve a wide range of applications. The resultant benefit to users is the ability to purchase a useful computer at a low cost. However, this generality results in a system which must be subsequently adapted to perform useful functions.

Software refers to computer programs. These programs contain lists of instructions that adapt the computer to a specific application by causing the hardware to act in a certain manner. An example of this adaptation is the common use of microcomputers as word processing systems even though the hardware is not specifically intended for that application. The term "software" originates from the notion that computer programs are easier to change than the hardware.

Software performs three major functions: (1) supervising the operation of the hardware, (2) performing computation tasks for end users, and (3) aiding computer users and programmers. The first function is handled by a set of computer programs which are collectively known as <u>systems software</u>. The second function is handled by <u>application programs</u>, and programs which handle the third function are called <u>software tools</u> or <u>software development aids</u>. Systems software is discussed in section 2.3, and application software is described in chapter 4, and software development aids are introduced in section 2.4.

2.2. MICROCOMPUTER HARDWARE

Figure 2-1 shows the components which comprise computer hardware and table 2-1 briefly describes their functions. Sections 2.2.1 through 2.2.8 discuss the

individual components and section 2.2.9 provides a brief overview of the technology used in these components.

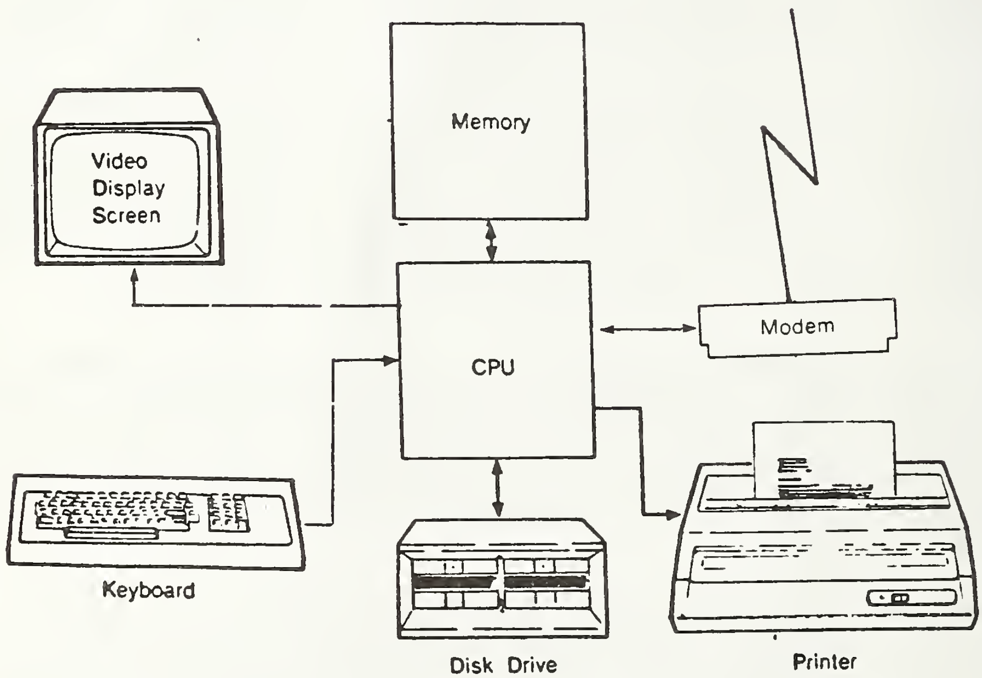


Figure 2-1. Microcomputer Hardware Devices

TABLE 2-1. MAJOR MICROCOMPUTER HARDWARE COMPONENTS

COMPONENT	DESCRIPTION
PROCESSING/MEMORY UNIT	Contains the central processing unit, memory, and circuitry for transferring data to and from the memory
DISK DRIVE	Storage of data when not being manipulated by the computer. Other devices which may be used for the same purpose include magnetic tape, bubble memory, or optical disks.
KEYBOARD	A typewriter-like arrangement of keys used for entering letters, numbers, and other information into the computer.
VIDEO DISPLAY SCREEN (or CRT)	A television picture tube-like unit which displays information generated by the computer.
PRINTER	Puts information on paper.
MODEM	Sends and receives data transmissions to and from other systems over telephone lines. Other means of computer communication which send signals through different types of cables (e.g. coaxial or fiber optics) are also available.

2.2.1. Processing and Memory

The heart of the microcomputer is the central processing unit (CPU), which is also referred to as a microprocessor (a microcomputer consists of the CPU, memory, and interfaces to peripheral devices). Most microcomputers are based on the microprocessors shown in table 2-2. The utilization of comparatively few CPUs has contributed to industry-wide standardization and the resultant wide acceptance of microcomputers. The most common descriptor of microprocessors is the number of "bits" (an acronym for binary digit, the smallest unit of information) that may be operated upon at one time. The first microprocessors operated on 4 bits in parallel; current microprocessors operate on 8, 16, or 32 bits.

CPUs that work with a large number of bits have three advantages over those that work with a smaller number: they process information faster, they have more instructions (i.e. they can do more), and they can access much larger amounts of memory. As a result, they can execute more sophisticated software and manipulate larger amounts of data.

The computer memory contains the program (i.e. the list of instructions) which the central processing unit executes. There are two types of memory, read-only and random access. Read only memory (ROM) is programmed at the factory and can not be written into by the user, i.e. it is permanent. ROM is useful for frequently executed programs that do not change. At least a portion of most operating systems is furnished as ROM. Many systems also include a common language processor such as a BASIC interpreter (discussed in section 2.4) in read only memory.

Unlike ROM, most random access memory (RAM) is volatile, i.e. when the computer power is turned off, its contents disappear. A benefit of the impermanence of RAM is that the function of the microcomputer may be changed by reading a new program into random access memory. By changing programs, the same hardware may be used for diverse tasks such as word processing or planning departmental budgets. Changing programs in read-only memory requires replacing the memory chips which are usually packaged in a "cartridge." This technique is used with some small portable microcomputers and pocket calculators.

Both RAM and ROM store bits in groups of eight bits called "bytes". Each byte may be used to store an encoded character such as a letter of the alphabet. The code for alphabetic and other characters has been standardized by the American National Standards Institute as the American Standard Code for Information Interchange (ASCII) and has been adopted by all microcomputer manufacturers.

Memory capacities are measured in kilobytes (abbreviated as Kbytes or "K"). Kilobytes are defined as having 1,024 bytes rather than 1,000 bytes because microcomputers use binary arithmetic and 1,024 is an integer power of two. For the applications in this report, microcomputer memories range from 64 to over 1,000K, and the trend is to larger memories as prices fall and more memory circuits are placed on a single integrated circuit (or "chip", see section 2.2.9).

TABLE 2-2. COMMON MICROPROCESSORS

NO. OF BITS	MANUFACTURER	DESIGNATION
8	Intel	8080, 8085
	Zilog	Z80
	Mostek	6502
16	Intel	8086, 8088, iAPX 186, 286
	Motorola	68000
	Zilog	Z8001, Z8002
	National Semiconductor	16032, 16008
32	Hewlett Packard	[undesignated]
	AT&T	BellMAC 32
	Intel	iAPX 432, 386
	Motorola	68020
	National Semiconductor	32032, 32132
	Zilog	Z80,000

2.2.2. Mass Storage

Mass storage devices including magnetic disks, tape, and bubble memory provide non-volatile storage which can be changed by the user (as opposed to ROM, which can not be easily altered). Because of the relatively slow access time on mass storage devices, data must be transferred to RAM before being used by the CPU. Therefore, mass storage is sometimes referred to as "external" storage in contrast to the "internal" storage provided by ROM or RAM.

Magnetic Disks

Magnetic disks are the most widely used form of mass storage because they allow relatively rapid access to any location on the disk. Three important factors affecting performance are:

Access time: the time necessary to reach a designated location on a disk (analogous to the movement of a phonograph needle to a point on a record).

Data transfer rate: the rate at which data can be transferred from the disk to RAM and back.

Capacity: the amount of data which can be stored on a disk. In general, large disk capacities are desirable.

Two types of disk storage units are currently available: "floppy" or flexible disks and "hard" or rigid disks. Floppy disks are generally less expensive but have lower performance than hard disks. Table 2-3 describes the various diameters and capacities of current floppy disks.

The most common rigid disk diameters are 8" and 5.25" ; the latter diameter is apparently emerging as the dominant choice of system manufacturers [KILL83, MILL83, DOHE83, JOHN83]. The capacity of 5.25" rigid drives is 10 to 20 Mbytes in current microcomputers, and current advances in storage technology make it probable that these capacities will increase many-fold. Some manufacturers offer drives which hold several disks with a resultant doubling or tripling of the storage capacity per drive. With most hard disks, the storage media are not removable from the drive. Thus, data backup (i.e. creation of duplicate copies of the data on an alternate storage device in the event of a disk failure) and off-line storage (i.e. placing the disk contents on a magnetic tape, floppy disk, or other medium which may be physically removed and stored) is desirable.

Magnetic Tape

Although magnetic tape was initially used as a data storage medium for microcomputers, the superior performance of disk drives has resulted in its being displaced as a primary mass storage medium in most systems. However, specially designed magnetic tape cartridge units are currently used to back up hard disks.

TABLE 2-3. FLOPPY DISKS

DIAMETER	CURRENT DATA CAPACITY*	COMMENTS
8"	241 Kbytes - 1.6 Mbytes	First introduced by IBM in 1970 for larger systems; low storage capacity data format is quite popular and is a ready means of exchanging data and programs with other systems.
5.25"	160 Kbytes - 2 Mbytes	Introduced by Shugart in 1976; became more popular than 8" drives because of smaller size. There are many different formats for 5.25" drives; thus, exchanging programs and data is often difficult.
Sub - 5"	125 Kbytes - 0.5 Mbytes	Sub-5" drives have the potential of offering shorter access times, higher transfer rates, and higher densities in smaller and more reliable units. However, at present, 5 different proposed standard formats in 4 different disk diameters and several alternative packaging techniques exist. None has yet emerged as dominant.

* Capacities of commercially available units as of mid-1983; capacities as high as 10 Mbytes have been announced for floppy disks using vertical magnetic storage technology [KILL83].

Other Technologies

Additional mass storage technologies are constantly emerging. Magnetic bubble memory is useful for mass storage in specialized applications where high reliability or low weight are considerations. Its disadvantages are higher cost and limited capacity. Optical disks may be useful for storing large amounts of permanent data, but the technology is still relatively new, and additional work on the basic technology, hardware interfaces, and system software is necessary for these devices to become practical for common applications.

2.2.3. Keyboards

Keyboards are the most common input device for current microcomputers and may be either an integral part of the case holding the video display or detached. In addition to the letters, numbers, punctuation, and special symbols typically found on typewriter keyboards, some microcomputer keyboards have special function keys. These keys allow the user to manipulate the display, memory, programs, or peripheral devices. Numeric keypads (i.e. those resembling adding machine keyboards) and cursor control keys (see section 2.2.5) are also found on many microcomputers keyboards.

2.2.4. Other Input Devices

Keyboards may be supplemented by other input devices including pointing devices, digital to analog converters, and voice input.

Pointing devices enhance operator convenience in such operations as making a choice from a list of options or indicating data to be acted on (e.g. designating a paragraph to be deleted from a document) and for performing graphics operations. Table 2-4 lists pointing devices which are commonly used for microcomputers.

Analog to digital conversion is useful in situations where temperature sensors (e.g. thermocouples or thermistors), pressure sensors (e.g. transducers), radiation detectors, or other devices may be the source of the input. In these cases, continuously variable analog voltages from instruments are converted to discrete digital form and read into the computer's memory.

Voice input devices are also available. The voice may either be recorded for subsequent playback or it may be analyzed by the computer in an attempt to recognize the word or sound. Unfortunately, the storage capacity of current microcomputers is too limited for lengthy messages, and systems that analyze and discriminate words have limited vocabularies and problems differentiating speech from ambient noise.

TABLE 2-4. COMMON POINTING DEVICES

DEVICE	DESCRIPTION
Mouse	The mouse is a small, hand held device which, when moved across a flat surface, causes a corresponding signal to be sent to the computer. The motion of the mouse may be detected using either an optical or mechanical system.
Light pen	The light pen is a pen-like device which detects changing light as it appears on a CRT screen (section 2.2.5) and generates a signal when this occurs. The time at which this signal is generated can be translated to a corresponding position through a part of the system software. The primary advantage of light pens is that the operator can rapidly move them to any point on the CRT. A disadvantage is that the operator must lean forward and touch the screen, an activity which can result in fatigue if performed frequently.
Joystick	The joystick is a finger-sized (or smaller) device which sticks out from the plane of the table or keyboard. It is connected to movement generators which send both horizontal and vertical signals to the computer depending on how it is manipulated by the operator. Although higher precision models are commonly used for computer aided design and drafting on larger computers, joysticks designed for microcomputers are typically low cost and low precision input devices which may not be suitable for many applications.
Digitizing tablet	A digitizing tablet is a special surface which may vary from the approximate size of an index card to that of a large drawing. This surface can sense movement of a stylus (or similar device) and transmit the data to the computer for subsequent processing.

2.2.5. Video Display Monitors

Video display monitors, also referred to as video display tubes (VDTs) or video display units (VDUs), are the most common output devices on current microcomputers. Because nearly all use cathode ray tubes similar to television sets, they are often referred to as CRT terminals or simply CRTs. Low-end microcomputers use television sets, but the display quality (i.e. the clarity with which characters are displayed) is generally poor. Such systems are not of interest for the applications covered in this report. Displays that are of interest may be characterized as follows:

Color or Monochrome

Typical color monitors can display from 8 to 265 different colors. Variations in color may be used for aesthetic value or to enhance the amount of information on the display (for instance showing negative numbers in red). Color displays are generally more expensive than monochrome displays and require more memory, either in the display unit itself or in the computer.

Monochrome displays have only a single, light foreground color, usually white, green, or amber. Some displays show dark characters on light backgrounds. The question of which combinations are best from the operator point of view is being studied, but there are no currently generally accepted conclusions [KETC82].

Character Oriented or Bit-Mapped

As shown in figure 2-2, characters are made up of discrete dots. To form a given character, certain dots in a matrix of possible dots are illuminated while others are not. A character oriented display can show only certain pre-defined patterns of dots which make up the 96 characters specified by by the American National Standards Institute (ANSI), and up to 128 additional characters. These additional characters may be used for foreign alphabets, geometric characters, and other special symbols, but they are not standardized and vary from manufacturer to manufacturer. Character oriented displays typically have a capacity of 24 or 25 eighty-character lines.

With a bit-mapped display, any dot can be turned on or off. This capability allows the creation of graphics, non-Latin characters, and many other features which are under control of software. Although bit mapped displays offer greater flexibility, they are more expensive and require more hardware and system software support than character oriented displays.

Whether a bit-mapped or character oriented display is used, the quality of the displayed characters depends on the number of dots making up each letter or number. There are significant legibility (and resultant eye strain) differences between characters made up of dots on a 9 by 14 matrix and a 6 by 9 matrix.

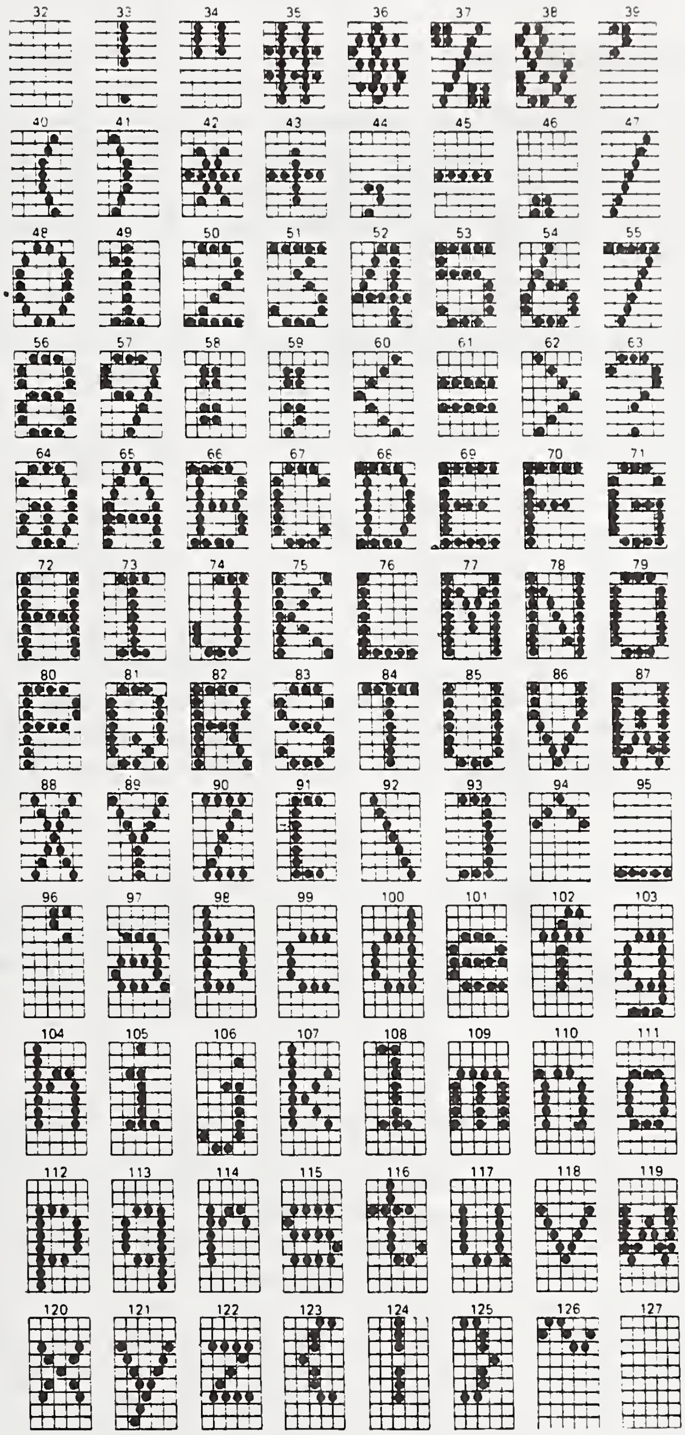


FIGURE 2-2. ASCII Characters displayed as a series of dots (from [IBM81] p. 3-17)

Memory-mapped and Serial Displays

A memory-mapped CRT displays whatever is placed in a certain portion of the computer's memory. This method facilitates the rapid change of the display. but requires additional memory and specialized interface hardware. Serial displays receive characters one at a time, and display them as they are received. Although this technique is slower and may not be suitable for graphics (up to 20 minutes may be necessary to fill a medium resolution -- i.e. 600 x 600 -- screen [DOHE83b]), it enables the manufacturer to use standard interface hardware and widely available CRT/keyboard units.

Flat Displays

The increased interest in portable computers has spurred the development of flat displays which do not use bulky cathode ray tubes. Currently, the most common types of flat displays use liquid crystals similar to those used in calculators and digital watches. These displays are generally small (from 40 to 320 characters) and difficult to read in dim light. Another type of flat display uses an array of tiny plasma-filled light bulbs which act as dots that can display characters and graphics in the same manner as CRTs. However, these plasma displays are more expensive than liquid crystal displays and require additional power, a problem in portable units.

2.2.6. Printers

Printers vary in many characteristics including paper dimensions, printing speed, printing methodology, quality, paper-handling, size, and noise levels. The methods for interfacing printers to the computers are also quite variable.

Speed and Throughput

Microcomputer printers generally print a single character at a time, and their speeds are rated in characters per second. Throughput, which may be as little as 1/3 of the character per second rating [PRES83], is based on the number of pages per unit time that can be printed. Throughput is a more realistic measure of productivity but can not be measured as easily as printing speed. Differences between throughput and printing speed can be due to the paper feed and print head positioning mechanisms or to the "intelligence" of the printer (i.e. not moving the print head to an area of blanks).

Printing Process

Mechanical or "impact" printers form characters by striking an inked ribbon against paper. Fully formed character printers strike a formed character, like a typewriter. Dot matrix printers make up a letter in the same manner as a CRT display. The fully formed-character printers (which are also referred to as letter quality printers) are generally slower and more expensive, but they produce higher quality output than dot matrix printers.

Most dot matrix printers work by striking pins against a ribbon. Some have multiple colors. These printers are nearly always faster than the fastest fully formed-character printers, but the dots making up a character are noticeable. Quality improvements in dot matrix printing include the use of more dots per character and the staggering of dots on a second pass. As was the case with bit-mapped CRTs, some printers are capable of printing individual dots, and graphics or custom type fonts can be drawn.

Nonmechanical printing processes include thermal and electrostatic techniques. These techniques are often used in small special purpose printers and may require treated papers [FOST83]. Newer techniques include ink jet printing and laser printing. Although promising, they do not yet provide the same quality as fully formed impact printing for a given cost.

Precision Positioning Control

Precision positioning control is the ability to position the printhead (the part of the printer which actually produces the character on the paper) at any point on the page with high precision (typically 1/120 " horizontal and 1/48 " vertical). This capability, when combined with the appropriate driver software in either the printer or the CPU allows the following features:

Variable pitch printing (i.e. the ability to print an "M" which is wider than an "l" and adjust the horizontal position of the printhead accordingly)

Proportional spacing or microjustification (i.e. the ability to vary the amount of space between characters for right justification)

Boldface printing (i.e. overstriking the same character with a slight offset to make it appear wider and darker)

Superscripts and subscripts

High quality graphics (see figure 4.7)

Paper Handling

Two common techniques of paper handling are used in printers: friction feed or traction feed. Friction feed uses a typewriter-like pressure platen to feed the paper through the machine. Traction feed uses two star-shaped wheels and pin holes in the side of the paper. Friction feed is useful for individual sheets and paper without the holes necessary for tractor feed (e.g. typical office stationery). Traction feed is useful for continuous printing involving a large number of sheets.

The most common types of printers will handle 8 1/2 inch wide sheets; printers handling sheets of up to 14 inches wide are also available.

Noise

Noise is an inevitable result of the mechanical nature of some printing processes. Dot-matrix printers are often quieter than fully formed character printers. Nonmechanical printing processes including thermal, chemical, ink jet, and laser printers are generally even quieter, but noise from fans or other auxiliary systems may cause problems.

Reliability

Because printers are made up of many mechanical parts, their reliability and maintainability may be a source of problems. Non-impact printers (i.e. thermal, electrostatic, or chemical printers) have fewer moving parts and thus have fewer breakdowns. Other non-mechanical printing technologies, for example ink-jet or laser printing are still relatively new, and not all performance and reliability problems have been solved in lower cost units.

Compatibility

Most current printers use internal microcomputers to control the printing process. These microcomputers are responsible for the "intelligence" of the printhead positioning mechanisms, the capability for producing graphics, and many other printing functions. Many of the functions performed by these printer microprocessors are under software control of the main CPU, and software compatibility must exist. The need for such compatibility can complicate the interfacing of a printer to a microcomputer. Thus, users should not assume that any printer will work with any microcomputer -- even if they both nominally follow the same standards for hardware interfaces and ASCII character sets.

2.2.7. Other Types of Output Devices

Additional types of output devices include plotters, digital to analog converters, and voice ouput.

Plotters are used for graphical output, and are available at low cost. In these devices, a pen is moved on the surface of a sheet of paper in order to draw graphs. Color graphs can be produced by plotters with multiple pens which contain different color inks. Plotters are useful in managerial, scientific, and technical applications.

Analog output is necessary for specialized laboratory or process control applications. Digital to analog converters (DACs) convert digital data (typically represented as 8, 12, or 16 bits) into a voltage level which can be amplified or otherwise manipulated externally.

Two general types of voice output devices are available: recorded vocabulary machines and voice synthesizers. Recorded vocabulary devices store a digital representation of a pre-recorded message and play it back without further processing. Two techniques are used for voice synthesis: one uses a mathematical formula to create a signal which simulates speech based on parameters stored in memory and the second uses a set of stored primitive

sounds ("phonemes") to assemble words. These voice synthesizers usually have their own microprocessors, and are programmed to accept standard characters (such as would be printed or displayed) and convert them to the appropriate phonemes for pronunciation. They are more flexible than the recorded-vocabulary machines, but less intelligible.

2.2.8. Communication Hardware

Hardware necessary to support communication can range from a simple cable to connect two serial or parallel interfaces (discussed in the next section) to complex circuitry involving data flow control, error detection and correction, and communication routing.

If the two systems are nearby each other (i.e. in the same room), then it is frequently possible to connect their output ports (see section 2.2.9) by means of a cable. Because it is often necessary to cross connect pins, the operation should be performed by someone who is technically qualified.

If the computers are to be connected over longer distances, modems can be utilized. Modems are devices which convert computer output to an analog signal for transmission over telephone lines (and also convert the analog signal to a digital signal at the receiving end). The range of options available on modems is quite large: simple units do little more than perform the digital to analog signal conversion; more "intelligent" units can automatically dial numbers, store messages for delayed transmission, and a number of other functions.

Specialized communication interfaces are necessary if the computers are to be connected to local area networks or other systems which use synchronous transmission or advanced communication protocols. A more detailed discussion of these topics is presented in section 4.5.

2.2.9. Microcomputers at the Component Level

Each of the devices described in the previous sections are made up of a number of different components. While most computer users need not concern themselves with the internal structure of the hardware, knowledge of some of the names and purposes of these parts may prove useful. Nearly all digital devices contain the following elements:

<u>Integrated Circuits</u>

Information processing is carried out in small electronic parts called integrated circuits (ICs). Advances in microcomputers are a result of increasing the number of functions that can be placed on a single integrated circuit. In the course of the last decade, ICs have moved from medium scale integration (MSI -- hundreds of transistors per IC) through large scale integrated circuits (LSI — thousands of transistors per IC) to very large scale integrated circuits (VLSI -- tens of thousands of transistors per IC). A single VLSI circuit can provide functions formerly found only in larger computers in a form that is inexpensive, reliable, and rugged. Some of the common types of integrated circuit are briefly described in table 2-5. However, several

of the functions described in the table are frequently found on a single IC. Figure 2-3 is a drawing of an IC and a socket (explained in the next paragraph).

Printed Circuit Boards

Integrated circuits are mounted on epoxy resin (i.e. plastic) cards and are connected to each other by pathways of copper bonded to the plastic surface of these cards. These cards are called printed circuit boards. The ICs may be soldered directly onto the boards or placed in sockets. Boards containing socketed ICs are more easily serviced, but are also more prone to failure and more expensive. Printed Circuit boards containing RAM ICs are frequently socketed to facilitate replacement of failed units. Figure 2-4 is a drawing of a printed circuit board.

Internal Microcomputer Buses

A microcomputer bus is a set of conductors which interconnects various functional groupings (e.g. memory, disk interfaces, CPU, etc.). Typically, a microcomputer bus consists of power, timing, data, address, and control lines. Many microcomputers are composed of a number of circuit boards which serve distinct functions (e.g. memory, disk drive control, CRT control, etc.). This design provides manufacturers and end users with more flexibility to meet individual requirements. If the bus design has been published and well documented (i.e. physical dimensions, electrical characteristics, line assignments, communications protocols, and timing are all specified), then third party vendors can supply additional boards which further enhance the functionality of the microcomputer. The Institute of Electrical and Electronic Engineers (IEEE) has published two standards for two buses: IEEE Std 696 (based on the MITS S-100 bus) and IEEE Std 796 (based on the Intel Multibus). Applications such as laboratory or field data collection may require the use of these standard buses for the connection of specialized devices. Standards for other microcomputer buses are currently being developed. Published specifications for the IBM PC and Apple II buses are also available, although these are not formal standards.

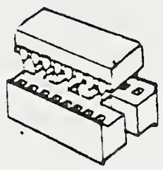


Figure 2-3. Integrated Circuit and Socket (from [IBM81] p. 3-117)

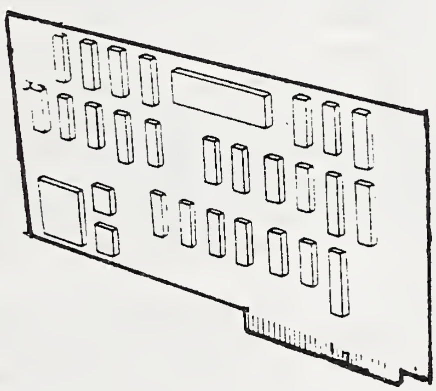


Figure 2-4. Printed Circuit Board (from [IBM81] p. 5-41)

TABLE 2-5. TYPES OF INTEGRATED CIRCUITS

CIRCUIT TYPE	PURPOSE
Microprocessor (CPU)	Functions as central processing unit of computer. Fetches data and instructions from memory, operates on data, and stores data back in memory.
Coprocessor	A specialized microprocessor that is activated by the CPU for specialized operations such as mathematical calculations.
Random Access Memory (RAM)	Contains electrical circuit elements which store binary data as the presence or absence of an electric voltage. Common RAM integrated circuits contain between 16,000 and 256,000 of these elements.
Memory Management Unit (MMU)	Partitions and controls memory areas for more rapid access, protection of critical areas, multitasking systems.
Direct Memory Access Controller	Directs data transfers between disks and blocks of memory without the need for CPU intervention.
Interrupt Controller	Interrupts the CPU (while it is performing another task, directs it to a specific set of instructions, and saves the results of the interrupted task to enable the CPU to continue processing when it finishes servicing the interrupt. Use of an interrupt controller enables the CPU to perform several different tasks simultaneously (e.g. printing one document while editing another).
UART or USART	Universal (Synchronous/) Asynchronous Receiver Transmitter. Controls transfer of data from the computer to an RS-232 or other type of serial port. Keeps track of timing, and status lines.
Modem	Modulator/Demodulator. A device which connects the microcomputer to a telephone, teletype, or intercom line.
D/A Converter (DAC)	Digital to Analog Converter. Converts the digital output of the microcomputer into an analog signal (typically a voltage)
A/D Converter (ADC)	Analog to Digital Converter. Converts an analog signal from a sensor (e.g. thermocouple or transducer) to a digital signal which can be processed by a microcomputer.

I/O Interfaces

Standardization is also necessary for the connection of peripherals (e.g. printers, plotters, communication lines, etc.) to the microcomputer. The most formal standard for this type of interface is a parallel connection which has been designated as IEEE Std 488. Unfortunately, two less standardized interfaces are far more common: the RS-232C interface is used for serial connections and the Centronics printer interface (named after a printer manufacturer which originated it) for parallel connections. Thus, end users should not depend on designations like "RS-232C" compatible as the assurance that devices from different manufacturers will function correctly when connected.

2.3. SYSTEMS SOFTWARE

Systems software consists of two parts: the operating system and utility programs. The operating system supervises the operation of the computer including control of peripherals and execution of programs. A very important function of the operating system is the transfer of data between the disk (or other mass storage device -- see section 2.2.2) and RAM; operating systems are sometimes referred to as disk operating systems or simply "DOS" for this reason. Utility programs enable the user to perform functions such as the routing of data and manipulation of files. Together, the operating system and the accompanying utilities form the software "backbone" of the computer. Table 2-6 describes the common functions of operating systems and associated utilities in more detail, and table 2-7 lists commonly available types of microcomputer operating systems.

Systems software is generally purchased with the microcomputer hardware, and all or parts may be stored in ROM. Many microcomputer manufacturers offer several different operating systems for their hardware, and independent software companies may sell their operating system for a given microcomputer, independent of the hardware manufacturer.

Two issues related to operating systems are important to microcomputers: compatibility with application software and the user interface.

Compatibility with Application Software

Operating systems are the "plug" into which the application software must fit in order to run on a microcomputer. In other words, application programs are written to be compatible with a specific operating system. Thus, the most important characteristic of an operating system is the availability of software pertinent to the intended use. Communities which include thousands of programs and vendors, magazines, users groups and clubs, conventions, books, and experts have been established for dominant operating systems.

For 8-bit machines, the CP/M operating system has predominated because hundreds of hardware manufacturers have adopted it. MSDOS, an operating system with design roots in CP/M, has become dominant in lower performance 16-bit systems. UNIX, an operating system that was developed

TABLE 2-6. GENERAL FUNCTIONS OF SYSTEMS SOFTWARE

FUNCTION	RELEVANCE	DESCRIPTION
Memory and Resource Management	All Users	Allocates system resources such as memory space, disk files, and I/O devices. Allows application software to access these resources.
Input and Output	All Users	Controls peripherals that are attached to the system (e.g. CRT, printers, plotters, etc.). Some operating systems also permit I/O redirection, i.e. the routing of data meant for one peripheral (e.g. printer) to another (e.g. disk).
Directory Maintenance	All Users	Maintenance of a list of file names, their location on the disk, size, protection state (e.g. read/write, read only, copy protected) and creation/last access date. Special features include hierarchical directories (useful for hard disks where hundreds of files need to be subdivided into groups), duplicate directories (a feature which enables the disk to be used even if the information in one directory is damaged), and hashed directories (an abbreviated portion of the directory is kept in RAM to facilitate faster disk access).
Utilities	All Users	Software which enables the user to copy, delete, rename, and compare files, to redirect I/O and reconfigure devices, to set time and date values, to display the status of various system units and resources, to format disks and generate new copies of the operating system. Popular operating systems are roughly comparable in these tasks; however, some might be more suitable for less knowledgeable users than others.
Command Processing	All Users	Each operating system provides a means by which the user executes programs (intrinsic or application-oriented). Both menu- and command-oriented systems are found on personal computers. Some menu-oriented systems use a mouse for selection rather than the keyboard. Most operating systems have provision for executing a series of programs or commands when the systems are started up or when the user types in a single command.

TABLE 2-6 (continued). GENERAL FUNCTIONS OF SYSTEMS SOFTWARE

FUNCTION	RELEVANCE	DESCRIPTION
Software Tools (or Software Development Aids)	Programmers	Software tools are programs which simplify the development of other software. A variety of tools are supplied with or can be purchased for development of software under any given operating system. These include assemblers and compilers, debugging monitors, disassemblers, cross-reference generators, program editors (some have syntax checking capabilities) and formatters (some have the ability to detect levels of nesting, beginnings and endings of blocks, and other structures which are indented or paginated accordingly), linkers, and file management utilities. Additional tools such as index management packages and form generators are generally offered from third parties.
Programmer Services	Programmers	Programmer services are related to software development tools but are an integral part of the operating system. These services typically include communication between concurrent processes, specialized support for screen-oriented I/O (e.g. cursor positioning, double intensity and reverse video, protected fields, etc.), graphic output, and support for menus (i.e. generation of menus and responding to user selection). These more sophisticated services may eventually result in superior user interfaces for both the operating system and application software. They may also enhance portability, particularly if a complement of standard or near standard services is established.

TABLE 2-7. CONFIGURATIONS OF OPERATING SYSTEMS

CONFIGURATION	EXAMPLES	COMMENTS
Single user/ single tasking	CP/M-80 CP/M-86 MSDOS (1,2) p-System	Single user/single tasking operating systems are the simplest and most common (as of 1983) operating systems. The cited examples have a large variety of application software, wide distribution, and support from a variety of sources. Although more powerful hardware and larger memory sizes are making more sophisticated operating systems feasible on microcomputers, single tasking operating systems will still be prominent on portable systems (because of limitations on memory and power consumption) and lower cost units.
Single user/ multitasking	Concurrent CP/M-86 MSDOS (3.0 and above)	Single user/multitasking operating systems were first introduced in 1983 and are becoming more popular on 16-bit (and higher) systems with larger amounts of memory (typically greater than 256K). Advantages include rapid switching between tasks and the concurrent execution of tasks that use dissimilar resources. The techniques for multitasking are well understood from the mainframe world. Its use in microcomputers allows a user to work with several tasks (e.g. communications, printing a job, and running a spread sheet) simultaneously. Major software development organizations are making a large investment in programmer development aids and graphically-oriented user interfaces for this class of system, and increasingly elaborate products will probably arise in the near future.
Multiuser	UNIX (and variants) MP/M Turbodos	Multiuser/multitasking systems allow several users to access the same resources simultaneously, and their primary advantage is to facilitate several users' access to common data. They are feasible for 16-bit microcomputers with large memories (512 K or above) and for multiprocessor systems (i.e. each user has a dedicated microprocessor which shares common system resources). Some systems were written to be compatible with earlier single tasking systems to allow use of existing software.

for larger computers, is now becoming popular for more powerful 16-bit and 32-bit microcomputers. Well over a dozen companies have implemented versions of it for 16 bit machines. Many microcomputer manufacturers offer several operating systems for their hardware, and application software companies have versions of their programs for more than one operating system.

Unfortunately, having the appropriate operating system is a necessary but not always sufficient condition for insuring that an application program will work with a given microcomputer. Use of special hardware features (e.g. bit mapping on a CRT or a dot matrix printer -- see section 2.2) may require special software modifications which must be performed by experts.

The Operating System User Interface

Interaction with the operating system occurs prior to executing application programs or after completing the task, when running utilities, and when changing the configuration of the computer (e.g. adding more memory or a new peripheral). Thus, the quality of the user interface (see section 2.5) affects all users -- even those who intend to do nothing more than execute a particular application program.

Because earlier operating systems such as CP/M, MSDOS, or UNIX were constrained by available memory and allowable processing overhead (i.e. the amount of time spent executing the operating system rather than the application), they provided only minimal user interface features. However, the advent of more powerful 16-bit processors, inexpensive memory, and numerous users without formal computer training encouraged a change in this situation. In 1983 several companies introduced operating systems with much more sophisticated interfaces [PETE83, WOOD83, LEMM83, HAYH83]. Commands may be entered through either the keyboard or by pointing to an option displayed on the screen with a device such as a mouse (see section 2.2.4). These operating systems also provide assistance through the use of help screens and easy transitions among tasks.

Whether these newer operating systems supersede the earlier offerings depends on acceptance by independent application software developers, end-users, and microcomputer manufacturers. Independent software developers will accept the systems if they can develop sophisticated user interfaces through the operating systems and the training, seminars, and technical literature provided by the operating systems vendors. Acceptance by end users depends on the availability of application software, price of both the operating system and application software, and the quality of the operating system interface (e.g. menus, on-line help files, support for point devices, ease of learning, convenience). Microcomputer manufacturers will adapt their hardware to software which gains widespread market acceptance (as defined by the number of purchases).

2.4. PROGRAMMING LANGUAGES

This section describes how software is developed and introduces the concept of programming languages. Computer programs are a sequence of instructions which the central processing unit (CPU) executes. These instructions may cause the CPU to fetch data from the memory, perform arithmetic operations, accept input, or send data to a peripheral device. These instructions are stored in the computer memory as a series of 1s and 0s, a form referred to as machine language or object code. Because machine language is difficult for people to work with and understand, language processors have been developed that accept instructions in a more usable form and translate them into machine language. As computer programming evolved over the past four decades, the following types of languages have evolved:

Assembly Language

Assembly language is a straightforward transformation of the machine language into a series of acronyms which help the programmer understand the nature of the commands. For example, a command which increments a number by 1 is represented as 00000100 in machine language but as INR in assembly language; a command telling the processor to move to a different area of memory for the next instruction ("Jump" to a different location) is represented as 1100011 in machine language and JMP in assembly language. An assembler is a program which converts assembly language into machine language. Assemblers have undergone a number of enhancements. The more sophisticated assemblers are referred to as "macroassemblers".

High Order Languages

High Order Languages (abbreviated as HOLs or HLLs -- High Level Languages) were first developed to aid scientists and engineers to perform calculations with a set of commands that was meaningful to them rather than in a language that could be processed by the CPU. Figure 2-5 demonstrates the purpose of high order languages. Both code fragments (these are not freestanding programs) represent the same process: integer division (the assembly language routine is restricted to 8-bit numbers, i.e. those less than 255). Figure 2-5 shows that unlike assembly language, there is no directly corresponding machine code for a high order language statement. Thus, a much more sophisticated process is necessary for translation of an HOL statement into a machine-executable form.

Two general approaches have been taken to perform this process: compiling and interpreting.

Compilers analyze HOL statements, decide (through a rather complex process) on the appropriate set of assembly language statements, and write these statements to a file. This file is then assembled into machine language. Some compilers perform the translation in several stages (called "passes"), and more sophisticated compilers have the ability to analyze the machine code generated by a first-pass compilation

8080 ASSEMBLY LANGUAGE

```
                         ; COMMENTS OCCUR AFTER SEMICOLON
                         ;
     MVI   E,DIVDND      ; store the dividend (defined elsewhere) in register E
     MVI   D,DIVSR       ; store the divisor in register D
                         ; because 8080 registers are only 8 bits wide
                         ;    both E and D must be integers less than 256

     (other code here including invocation of subroutine DIV)

DIV:                     ; DIV is label (i.e. address) of the division subroutine
     LXI   B,9           ; load register B (a counter) with the number 9
NXT: MOV   A,E           ; move the divisor (register E) to the accumulator
     RAL                 ; rotate the most significant bit of A to the carry
     MOV   E,A           ; save the dividend back in register E
     DCR   B             ; decrement the counter in register B
     RZ                  ; if the counter is 0 then exit the subroutine
                         ; ...else move the partial result to A
     MOV   A,C           ; C is used to store the partial dividend result
     RAL                 ; rotate the most significant bit of A to the carry
     SUB   D             ; subtract the divisor from A
     JNC   NOAD          ; if the carry flag is not up then jump to NOAD
     ADD   D             ; ...else add the divisor back to A
NOAD:
     MOV   C,A           ; move the partial dividend from A to C
     CMC                 ; set/clear carry flag by complementing
     JMP   NXT           ; repeat this sequence of operations
```

HIGH ORDER LANGUAGE

```
E = E/D
```

Figure 2-5. Assembly Language [TITU78] and High Order Language representations of a division of two numbers.

and generate more efficient (i.e. shorter) assembly language programs or machine code.

Interpreters do not generate machine code, but perform the translation of the HOL statements at the time of execution. As is the case with compilers, interpreters can work in several stages: the HOL programs are translated into an intermediate form, and the interpreter translates this intermediate form into machine code at the time of execution. This two-step process speeds execution (which may be unacceptably slow if HOL statements are interpreted directly) and may also reduce memory requirements.

The advantages of HOL programs are that they take less time (i.e. are less costly) to develop, easier to correct and change, and can be taken from one microprocessor to another without the need for extensive revisions (such is not the case with assembly language programs). It is for these reasons that HOLs are used for most applications and some systems programming. Table 2-8 shows some of the HOLs used in microcomputers.

The disadvantages of HOLs are that they result in code which requires more memory and takes longer to execute than programs written in assembly language. The relative disadvantages of HOLs are dependent on the quality of the compiler or interpreter, the nature of the HOL, and the micrprocessor instruction set (i.e. the repertoire of operations which the microprocessor is capable of executing). Early microprocessors (such as the 8080) were not intended for high level language programming, and compilation of common high order languages into their instruction sets is not efficient. The instruction sets of newer microprocessors are advertised as being designed specifically for the use of HOLs [MARK81].

Very High Level Languages

Very High Level Languages (VHLLs) resemble natural language most closely and are the least computer-oriented. Many VHLLs do not even resemble the sequences of instructions seen in the two previous classes of languages. All require extensive preprocessing prior to execution, and most are oriented toward a specific end (e.g. generation of a report, storage and retrieval of information, solution of a set of equations, etc.). VHLLs provide the most rapid means of developing application software. It is possible to characterize two types of microcomputer-based VHLLs: generic application programs and program generators.

Generic application programs include spread sheet processors, data file managers, and other applications (see Chapter 4) which can be used to perform many of the tasks that were traditionally programmed in HOLs. These packages do not require extensive programming skills and can be used by personnel with little or no formal computer training (although some initial support may be necessary).

Program generators are computer programs that generate other computer programs in a formal HOL. They are a means of speeding software development for programmers, but whether they can be used effectively by

TABLE 2-8. COMMON HIGH ORDER LANGUAGES USED IN MICROCOMPUTERS

LANGUAGE	APPLICATION AREAS	COMMENTS
BASIC	All	BASIC (Beginner's All-purpose Symbolic Instruction Code) was originally developed as a language to teach computer programming to university students in the 1950s. Because of its initial simplicity, it was the first HOL implemented on microcomputers, and has been offered as a standard accessory on nearly every microcomputer system. It has been extended far beyond its first capabilities, and has become the most popular language for microcomputer programming. Unfortunately, the numerous extensions have also resulted in there being many incompatible dialects.
Pascal	All	Pascal was developed in the early 1970s also in an academic environment. The primary goals of its developers were to encourage the use of structured programming and the generation of readable and maintainable programs. Pascal became popular because of its early implementation on microcomputers for courses in computer programming in the mid 1970s. Although it will probably not surpass BASIC as the most widely used microcomputer language, its programming constructs, data types, and software engineering pedigree make it a language of choice for many software developers.
COBOL	Managerial and Administrative	COBOL (COmmon Business Oriented Language was initially developed in the early 1960s for administrative purposes, and has become the single most popular programming language for mainframe computers. Its specialized features for data entry and data management (with the use of additional utilities) have made it attractive for the same purposes on microcomputers. Although not efficient in its use of memory and slow in execution, its mainframe heritage, data handling capabilities, and accompanying utilities have made it a popular language for business oriented applications on microcomputers.

TABLE 2-8. COMMON HIGH ORDER LANGUAGES USED IN MICROCOMPUTERS

LANGUAGE	APPLICATION AREAS	COMMENTS
C	Systems	C was originally developed in the Bell Laboratories by the writers of the UNIX operating system. As a consequence of the wide use of UNIX in the academic community, C became quite popular with computer science students who took their preference for the language (as well as UNIX) to their jobs in industry. C became popular as a systems development language for microcomputers soon after the introduction of 16-bit microprocessors, when the first microcomputer software conversions became necessary and the adequate computing power became available.
FORTRAN	Scientific/ Engineering	FORTRAN (FORmula TRANslation) was developed in the mid-1950s, and was the first high order computer language. It is the most popular language for scientific and engineering applications on larger systems, and most FORTRAN compilers generate faster and shorter machine language programs than those of other languages. Like COBOL in the administrative area, its mainframe heritage and large software installed base makes FORTRAN a language of choice for many technical applications.
FORTH	Real time applications, Systems Programming	Forth is the first major HOL to be developed on and for microprocessors. Its applications unique approach to program creation involves the building of code in terms of procedures which are in turn defined by lower level procedures. Several levels may be built up over the lowest layer. This approach results in the generation of very compact code which can be used in devices where memory is constrained (e.g. micro-controllers).

non-programmers is not clear [STEW82, KILD83]. Most microcomputer-based program generators are oriented toward administrative and managerial users and include features for creation of records and files, data entry, and report generation. They are therefore similar to data file management systems (section 4.3) but may provide more flexibility for some applications because of their use of HOLs.

2.5. THE USER INTERFACE

The user interface is that portion of the hardware and software that is visible to the user. Although not sufficient in and of itself, a good user interface is a necessary condition for successful microcomputer implementation. Unfortunately, no definitive standards have emerged on what constitutes a quality user interface, and some authors [SIMP82, CHAF83] maintain that a good design is an art which can not be stated in a set of rules. Nevertheless, progress in this area is evident in both the technical literature and, more significantly, available hardware and software products.

2.5.1. Hardware Aspect of the User Interface

The hardware aspect of the user interface is the physical interaction of the user with the equipment. The study of this interaction is called "ergonomics" or "human engineering". The following characteristics of the CRT, keyboard, and general system are usually cited as being important [PRES83, KETCH82, COHE82].

CRT

Display quality is important for minimizing discomfort for heavy users. Factors affecting this quality include the high resolution and well-focused characters, non-glare screens, separate brightness and contrast controls, and adjustments for the screen height and angle. Issues such as color (white, green, or amber on black) and background (light on dark or dark on light) are a matter of individual taste. Thus, the availability of options is desirable. Oversize screens (i.e. larger than 80 columns by 24 lines) with high resolution bit mapping have been used by several manufacturers as a means of enhancing the user interface in more expensive units.

Keyboard

A detachable keyboard allows greater flexibility in system placement and the ability to enter data while facing the work rather than the CRT. Keys that provide tactile feedback similar to a quality electric typewriter are desirable for constant users. A keyboard with an adjustable angle relative to the surface on which it rests and sculptured keys can reduce fatigue.

General system

The most important characteristic of the user interface is reliability. Other factors include a visually pleasing and unobtrusive design, low space requirements, low noise, and low heat generation.

2.5.2. Software Aspect of the User Interface

Chafin [CHAF83] has noted that ergonomics is particularly important for heavy users but there is some question as to whether these issues are significant for users who interact with the system for shorter periods. However, the

software user interface affects all users: an application program which is difficult and/or frustrating to use will not be utilized regardless of the quality of the hardware on which it runs. As was the case in hardware, there are few firm guidelines on characteristics of a quality software user interface. The following list of features is gathered from a number of recent articles in this area [CHAF83, BO82, SMIT82, RUTK82].

Feedback to the User

Feedback is important for informing the user of the progress of execution, the presence of problems, and the data which is being operated on. Features in this area should include:

A prompt or message indicating when the program expects an input from the user

The display of data input by the user

Some means of indicating the progress of a lengthy operation (e.g. transmission of a file, disk formatting, or a sort)

Consistency

A command or keystroke should have the same meaning in every phase of the program execution (or, if possible, in all programs). For example, if the letter "A" is used for an "Append" command during data entry, it should not mean "Abort" in the execution phase of the same program.

Minimization of Demands on the User's Memory

Both common experience and experimental evidence indicate that recognition is easier than recall [BO82, CHAF83, SMIT82]. Thus, the software should provide some coaching for users as they proceed through the various command sequences of a program. Menus which list available options and help screens which display instructions during program execution are the most common means of providing this assistance. However, these measures may prove cumbersome for users already familiar with the program. The best solution is the provision of a "verbose" mode which enables a novice or casual user to utilize the menus and help screens and a "terse" mode which provides relatively little prompting but allows an experienced user to enter commands rapidly.

Additional features can minimize demands on the user's memory for data entry and manipulation. The ability to use parts of the same CRT display for noncontiguous areas of data (e.g. the display of two different pages of text or nonadjacent columns on a spreadsheet) can be quite useful.

Simplicity

Simple arrangement of operations, commands, and displays minimize what the operator must know in order to utilize the software. Simplicity does not mean that a complete set of user prompts or necessary functions should be deleted. However, it does require that the software developer

understand the application (i.e. what is necessary, when it is necessary, and what is unimportant) and is generally the result of good program design.

Error Handling

Error handling provisions inhibit operator errors, enable the correction of mistakes, and allow recovery from system faults. Among the commands which can be provided are:

Ability to interrupt operations without aborting the application and losing data

An "undo" command which allows the reversal of the last command (e.g. restore data which was deleted by a previous command)

Editing of the current input line (e.g. the ability to erase part of a command line or to replace one or two digits in a long string of numbers)

Automatic creation of backup copies of data files

Other provisions for error handling include:

Messages which clearly indicate the error condition and suggest remedial action

Detection and recovery from system faults (e.g. disk not ready, printer out of paper, etc.)

Confirmation of potentially catastrophic commands prior to execution (e.g. deletion or overwriting of an existing file)

Non-character Interactions

The use of (i.e. the ability of the software to support) pointing devices (section 2.2), color, voice, graphics, and other non-character means of data interchange can be useful for both program control and data displays. At present, such facilities are offered on more expensive microcomputers and a lack of standards prevents the interchange of such information between different systems. However, continued progress in this area is likely and will increase the effectiveness of microcomputers in all areas of the organization.

2.6. TYPES OF MICROCOMPUTERS

The expanding market for microcomputers has resulted in a plethora of products with a variety of differing attributes. This section discusses three different viewpoints that may be useful for categorizing the different types of systems which are available. Section 2.6.1 discusses categories of microcomputer functions; section 2.6.2 classifies microcomputers on the basis of size and weight, and section 2.6.3 describes the differences between single and multiuser systems.

2.6.1. Function

Four major categories of microcomputer functions can be established: general purpose, word processing, education or entertainment, and laboratory automation or process control.

General Purpose Systems

General purpose systems are appropriate for most Federal microcomputer applications, and are the most common type available for business and professional use. General purpose systems are produced in all size classifications and in both single and multiple user configurations. The most significant characteristic of these systems is their compatibility with a wide variety of application software and peripherals which enables them to perform tasks useful to all user classes. Other characteristics include high quality keyboards and CRTs, large capacity disk drives, and application program development aids.

Word Processing Systems

Word processing systems are microcomputers which have hardware and software features designed for word processing and associated functions (e.g. mailing lists, form letters, etc.). Some systems may be adaptable to more general use by adding a standard operating system and/or special hardware attachments. It is not clear whether these dedicated function systems will continue as distinct products [HOUS82] because the smaller demand leads to higher prices than general purpose systems. However, others feel that the productivity benefits derived from special hardware and software features in these single purpose microcomputers outweigh the cost disadvantages. These systems have been designed primarily for clerical users, but some administrative users with typing abilities may be able to benefit from the electronic mail and document production capabilities present in more sophisticated systems.

Educational/Entertainment Computers

Microcomputers oriented toward educational and entertainment use possess a number of interesting features such as color graphics (low resolution), music, and games software. Their low price and appealing software make them appropriate for some Government training, education, and entertainment activities. However, few applications and languages necessary for performing normal business functions are provided. Thus, despite their very attractive hardware price/performance ratio, they are not suitable for most Government use. Other designations for this type of system include "home computers" or "domestic computers".

Laboratory Automation and Process Control

Microcomputers can be used for laboratory automation, automated testing, unattended data collection, and related functions. These microcomputers may use special operating systems and interfaces, but typically are built around an industry standard bus. These systems are most appropriate for

specialized applications required by professional and technical users. Although these microcomputers can be adapted to more general purpose uses in many cases, they may be more expensive and therefore less cost-effective.

2.6.2. Size and Weight

Three major categories of microcomputer size and weight are currently available: portable, transportable, and desktop.

Portable Computers

Portable computers, also called briefcase, lap, or notebook computers, are designed to fit into a briefcase and can be worked on in the user's lap while traveling or away from a table. Some very lightweight systems have limited memories and displays. However, their software offerings include a text editor, communications package (generally ASCII/TTY), a programming language (generally), and other applications which make them appropriate to Government use. More capable systems (which are generally heavier because of their larger batteries) may have adequate memory capacities (both volatile and nonvolatile) to support a standard operating system and applications.

These systems are appropriate for personnel who need access to a computer while away from a desk (e.g. traveling or field work). Their limited hardware capabilities (especially in peripherals) and resultant limitations on software make them less desirable than other types of systems in non-mobile applications. However, advances in both volatile and nonvolatile memories, displays, and lower power microprocessors may lead to systems with the same capabilities as present stationary microcomputers.

Transportable Computers

Transportable computers are designed to be moved frequently. They generally weigh between 5 and 15 kg (11 to 33 pounds), and are packaged such that they can be "folded up" into a suitcase-like package. They differ from the previous classification of computers because their greater weight and size preclude their use away from a desk.

The hardware capabilities of these systems span the range from portable computers to the desktop systems described below. Lighter systems with battery power have limited capacities. Heavier systems or those requiring external power have greater capabilities and may in fact be used in the same manner as some non-movable systems.

Transportable systems are appropriate for those who perform computing at a number of different locations, but who do not require the systems while en route or in places where power is not available. However, despite the fact that the computing functions may be equivalent, transportability precludes the use of full sized CRT displays and other peripherals.

Desk Top Systems

Desk top systems are the most common size of microcomputers and are appropriate for most Federal applications. They range from the size of a typewriter (useful where surface space is limited) to that of a desk including self-contained work surfaces (suitable for some clerical uses).

2.6.3. Number of Users

Microcomputers can also be characterized as either single or multiple user systems.

Single User Systems

Single user microcomputer systems embody the notion of "personal computers" in that one person has control over the entire system. They are the most common type of microcomputer, and both their hardware and software capabilities have increased dramatically since their introduction in 1977.

Multiuser Systems

Multiuser microcomputers have large memories and powerful processors, and are therefore sometimes referred to as "supermicrocomputers". They are used in many situations where smaller minicomputers would have applied previously. They do not provide their users with the total control of single user systems, but are appropriate when a group works together.

Because of the specialized operating systems required for some multiuser computers, fewer software offerings are available than for the single user systems, and the application software running under these systems is also generally more expensive. A second disadvantage is the possible lowering of performance when many users share a single CPU. However, the emergence of UNIX and variants in microcomputers as well as the availability of new high performance 16 and 32 bit microprocessors may change this situation. A special class of multiuser systems is called multiprocessor systems because they contain several CPUs. One advantage of these systems is faster response time. A second is the ability to assign each user a CPU and to use a common operating system.

CHAPTER 3 - FEDERAL USERS

This chapter classifies Federal microcomputer users, describes their characteristics, and identifies some of the issues related to their use of microcomputers. The user classification contains the following four categories:

Clerical

Clerical users include typists, junior secretaries, and data entry personnel. Most clerical uses of microcomputers involve data input (either numbers or text) formatting, or transcribing. Document preparation and administrative data entry are the most common applications of microcomputers.

Administrative

Administrative users of microcomputers include managers and other Federal workers whose primary responsibility is related to administrative tasks. Administrative uses of microcomputers include accounting, budgeting and planning.

Professional

Professional users include natural and social scientists, educators, legal workers, and others working in professional fields. Their uses of microcomputers include data analysis (primarily statistics), modeling, and document preparation.

Technical

Technical users include programmers, engineers, and researchers who perform their own computer-based system design and programming. The primary distinction between technical and professional users is the extent to which they perform their own programming.

Table 3-1 lists examples of job functions falling into these categories, and table 3-2 describes their distinguishing characteristics. Some users fall into several categories simultaneously. For example a legal secretary in the U.S. Courts performs administrative functions in addition to straight clerical duties. Sections 3.1 through 3.4 discuss these classifications in further detail.

TABLE 3-1. JOB FUNCTIONS OF THE USER CLASSIFICATIONS

USER CLASSIFICATION	EXAMPLE JOB FUNCTIONS
CLERICAL	Secretaries Clerk typists Cashiers Data Entry Clerks
ADMINISTRATIVE	Managers Administrative assistants Budget analysts Contract administrators Accounting and auditing staff Project managers
PROFESSIONAL (not in the computer field)	Economists Lawyers Doctors Law enforcement personnel Tax auditors Cartographers Librarians Historians Educators Scientists (some classes) Writers and Editors
TECHNICAL (in computing or related technical fields)	Computer Scientists and programmers Engineers Advanced technicians and technologists Scientists with computer backgrounds

TABLE 3-2. CHARACTERISTICS OF USER CLASSES

CHARACTERISTIC	CLERICAL	ADMINISTRATIVE	PROFESSIONAL	TECHNICAL
Scope of computer related tasks	Specia-lized	Broad	Broad	Broad
Necessity of computer-based systems for job	High	Low	Low	Variable
Computer Background	Limited	Limited	Variable	Substantial
Relative amount of system usage	High	Low	Low	High
Tolerance for malfunctions, problems	Low	Low	Low	Variable
Availability of personnel for extensive training	High	Low	Low	Low
Need for subsequent support	High	High	Variable	Low
Need for technical information	Low	Low	Low	High

CHAPTER 3 - Federal Users

3.1. CLERICAL USERS

Table 3-3 relates the important characteristics of clerical users (taken from table 3-2) to desirable attributes of their microcomputer systems. System reliability, a well designed user interface (see section 2.5), high performance, and effective documentation written for users with limited technical backgrounds are requirements which clerical users have in common with other users. In addition, the following specific issues exist for this user class:

Limited Scope of Computer Related Tasks

Unlike other users, many clerical workers perform tasks of limited scope (e.g. data entry, document preparation). For these workers specialized systems which provide large screens, function keys (i.e. keys which execute a series of commands or common keystrokes with a single key), specialized pointing devices, and other features that reduce fatigue and make systems easy to use are more suitable than general purpose systems.

Extended Use

Concerns on both the physiological impacts of CRTs and psychological effects of extended computer usage have been raised in the United States, Canada, and Europe [BOND83]. However, no definitive conclusion could be reached from research on the effects of CRTs on vision, pregnancies, cancer incidence rates, and musculo-skeletal well being. Ketchel [KETC82] lists some widely accepted ergonomic guidelines for CRTs, but also states that the research base on which to establish standards is not adequate.

Other measures to benefit clerical users (and improve performance) are related to lighting, noise, and furniture. Ambient lighting should be dim with higher intensity lighting on the work which operators are transcribing. Printers and other noisy devices (e.g. disk drives) should be hooded or placed in other rooms. Chairs and desks should be designed for both operator comfort and efficiency. Provisions in the layout of individual work stations as well as the entire work area should allow for the special requirements of CRTs, keyboards, printers, and other devices.

A recent National Institute of Occupational Safety and Health (NIOSH) study of clerical CRT operators investigated psychological and social effects [COHE82]. As a result of the introduction of large computers, office work began to resemble an assembly line with production quotas and rigid work assignments. This change resulted in increased stress levels for clerical workers. Microcomputers can potentially cause the same types of problems. However, because microcomputers allow the operator more control over the system, it is possible to avoid the assembly-line nature of work. Tasks can be structured in a less restrictive manner to minimize the negative impact on clerical users.

TABLE 3-3. CLERICAL USER CHARACTERISTICS AND DESIRABLE SYSTEM ATTRIBUTES

USER CHARACTERISTICS	DESIRABLE SYSTEM ATTRIBUTES
Specialize in limited range of computer related tasks	Systems with extra features for performing a limited set of tasks may be preferable to general purpose microcomputers.
Necessary to use microcomputer for job	High system availability is required. It is desirable that the microcomputer offer some gratification in the course of use.
Limited computer background	Training, documentation, and the user interface (section 2.5) must be appropriate for this level of computer expertise.
Low tolerance for malfunctions and problems	Reliable equipment with high level of maintenance is necessary.
Large portion of day spent using microcomputer based system	Keyboards, CRTs, work surfaces, chairs, lighting, noise levels, and other environmental factors should be controlled.
Need for formal and extended training period (days to weeks)	Extensive training should be provided as part of computer installation and for new users; software user interface should allow for several levels of expertise (see section 2.5).
Need for subsequent support is high	System design, procurement, management, and operation should anticipate the need for extensive user support. Support requirements may consume more departmental resources than system acquisition.

Training

Effective training is necessary to provide clerical users with both the expertise and confidence necessary to master their systems. For example, Ketchel [KETC82] points out that approximately six weeks are required to gain proficiency in word processing, but most vendors provide less than three days of instruction. During the remaining five weeks, the organization should provide additional training (perhaps through seminars and close work with more experienced users) as well as a lighter workload.

3.2. ADMINISTRATIVE USERS

Table 3-4 shows the important characteristics of administrative users (taken from table 3-2) and the resultant requirements on microcomputer systems. System reliability, a convenient user interface, high performance, and effective documentation written for users with a limited technical backgrounds are requirements which administrative users have in common with other classes. Special issues for this class of users include the following:

Support

As a result of the unpredictable nature of some aspects of administrative and managerial work and the need for rapid response, administrative users require a high level of support for their microcomputer related tasks [FERR82, SMEJ83, STJO82]. Such support can only be provided if the software, hardware, and communications (see section 5.3) are coordinated through a central support organization.

Validity and Control of Administrative and Financial Software and Data

Applications relating to accounting, personnel, and other administrative tasks which are performed on microcomputers are subject to a number of laws (e.g. The Paperwork Reduction Act, the Privacy Act, or the Freedom of Information Act), rules (e.g. OMB Circular A71), and guidelines (e.g. [GAO78]). Users with cavalier attitudes toward checking their results can cause incorrect data to propagate through the organization.

Additional concerns are related to data validity, protection, and access. The transfer of data files from a mainframe computer to a microcomputer means that in addition to ensuring data security (i.e. validity, protection, and access control) at the central site, the activities of users at dispersed locations must also be monitored.

TABLE 3-4. ADMINISTRATIVE USER CHARACTERISTICS AND DESIRABLE SYSTEM ATTRIBUTES

USER CHARACTERISTIC	DESIRABLE SYSTEM ATTRIBUTES
Broad Scope of Computer-related tasks	Hardware, system software should be compatible with popular application software. Flexibility is more important than extended features in one given area. Integration of application software is desirable (see section 4.7).
Microcomputer can be helpful but is not required for performing job	The system should be easy to learn and provide a rapid response so that the productivity benefit is immediately apparent.
Limited technical background	Software should be designed with an appropriately oriented user interface (see section 2.5). Documentation must be easy to understand. On-line help or tutorials desirable.
Smaller portion of day spent using computer	The physical impact of the system should be minimized. Documentation should be easy to read and designed for quick reference (e.g. summary sheets, indices, reference cards)
Low toleration for system malfunctions	Hardware and software reliability, availability of spares, and short time to repair are crucial. Overall availability is more important than capacity, performance and technical sophistication.
Short time available for training	Software must be easy to learn -- preferably without requiring more than a short period of reading prior to getting started. Help screens, menus, and user interface features (section 2.5) should be oriented to minimizing what the user must know in order to work with the program.
Extensive need for subsequent support	Readily available source is required for answering questions, solving problems on system operation, software commands, initiating repairs, and other user needs. Rapid response time necessary because of short turnaround time for many administrative tasks.

3.3. PROFESSIONAL USERS

Table 3-5 relates significant characteristics of professional users (taken from table 3-2) to desirable microcomputer system characteristics. System reliability, a convenient user interface, high performance, and documentation for users with limited technical backgrounds are requirements which professional users have in common with other classes. The following issues affect professional microcomputer users:

Application Development

Although the microcomputer industry has addressed the needs of clerical and administrative users with a large number of products and services, this has not been the case for many professional applications because of the much smaller market. Most professional workers are not skilled programmers nor is it cost effective to use their time for software development. Thus, professional users must resort to adapting existing packages to their needs (e.g. using a data base management system for statistical calculations), using software available on larger systems, or performing the calculation by hand. The extent to which new software development or conversion of existing software resident on mainframes to microcomputers should occur is not clear given their current hardware and software limitations. Unrealistic central computing charges can encourage microcomputer software development or conversion of mainframe software to microcomputers where it is not warranted.

Support

The most effective support personnel in highly professional settings are those who have a background in both the profession (e.g. medicine, geology) and in computing. Such personnel are rare, and their ability to support dispersed users (as opposed to more geographically concentrated users working on a single mainframe or minicomputer) is limited.

TABLE 3-5. PROFESSIONAL USER CHARACTERISTICS AND DESIRABLE SYSTEM ATTRIBUTES

USER CHARACTERISTIC	DESIRABLE SYSTEM ATTRIBUTE
Broad Scope of Computer-related tasks	System flexibility is more important than extended features in one given area. The hardware and system software should be compatible with standard applications (see chapter 4) and profession-specific software packages. System flexibility is more important than extended features in one given area.
Microcomputer can be helpful but is not required for performing job	Hardware, software must be easy to learn and use. The performance of the microcomputer should demonstrate an immediate productivity benefit.
Smaller portion of day spent using computer	Impact of system on work area should be minimized: small size, no extra power requirements, low noise, minimal extra cabling, etc. Documentation should be easy to read and designed for quick reference (e.g. summary sheets, indices, reference cards).
Varying expertise in computing	Software should be designed with an appropriately oriented user interface (see section 2.5). Documentation must be easy to understand. On-line help or tutorials are desirable. More technically sophisticated users may need systems and software with more features and higher performance.
Low to high toleration for system malfunctions	Use of microcomputers as adjunct to daily tasks requires high availability which impacts maintenance and support considerations. Some users may not be as affected by malfunctions and can tolerate longer down times and may have more flexibility in their choices of systems and capabilities.

TABLE 3-5 (continued). PROFESSIONAL USER CHARACTERISTICS AND DESIRABLE SYSTEM ATTRIBUTES

USER CHARACTERISTIC	DESIRABLE SYSTEM ATTRIBUTE
Short time available for training	Software must be easy to learn -- preferably without requiring more than a short period of reading prior to getting started. Help screens, menus, and user interface features (section 2.5) should be oriented to minimizing what the user must know in order to work with the program.
Need for subsequent support	Most users need a local source for answering questions and solving problems on system operations. Some may require profession-specific advice in conjunction with their computer-related inquiries.

3.4. TECHNICAL USERS

The important characteristics of technical users (taken from table 3-2) and the resultant desirable system qualities are shown in table 3-6. Technical users have some requirements in common with other users (e.g. reliability, documentation, and technical support). However, because of their knowledge of systems and their ability to program, technical users may find that systems designed for less sophisticated users are too limited in flexibility, performance, or capabilities. Some of the issues for technical users include:

<u>System requirements at variance with other users</u>

For specialized and advanced microcomputer applications (e.g. laboratory automation, data collection, or process control), technical users may require systems that are not the same as those used by the rest of the organization. Thus, agency policies on microcomputer procurement and usage should not inhibit the use of "non-standard" systems when needed. Conversely, technical users should recognize the importance of support, ergonomic, and related needs of non-technical users they may be asked to assist.

<u>Alternatives to microcomputers</u>

A large body of software, expertise, and peripherals has grown around dedicated minicomputers in process control, laboratory automation, and other specialized tasks. Although the price/performance ratios of microcomputer hardware are superior to those of some larger systems, both technical users and project managers should note the relative immaturity of microcomputers and the consequent paucity of support in any but the most "mainstream" of applications.

<u>Integration with larger systems</u>

Technical users who need to integrate mainframe software with a microcomputer applications (e.g. a package which queries a database on a central mainframe and presents the data to the user through a spread sheet program) face difficulties because there are no widely accepted standards for passing graphical or spread sheet data (see Chapter 4).

TABLE 3-6. TECHNICAL USER CHARACTERISTICS AND DESIRABLE SYSTEM ATTRIBUTES

USER CHARACTERISTIC	DESIRABLE SYSTEM ATTRIBUTE
Broad Scope of Computer related tasks	System compatibility with advanced and sophisticated application, utility, and systems software is important.
Varying necessity for microcomputer job functions	Microcomputers in daily use must have high availability -- possibly at some performance penalty. Systems used for research and development should have more advanced features and higher performance.
Technical backgrounds	Technically sophisticated documentation at a sufficient level to facilitate modification (for both hardware and software) is highly desirable. Elaborate user interfaces, introductory-level documentation are less important. Systems with provisions for software development and hardware interfacing may be desirable.
Some portion of day spent using system	For casual users, minimization of the system impact on the user's system working area of microcomputer is desirable (small size, no extra power, low noise, minimal extra cabling, etc.). To steady users, performance, reliability, ease of use are more significant. For both constant and casual users software commands should be uniform, self-evident.
Variable toleration for system malfunctions	System performance, capabilities, price may be more important than overall reliability to users who can tolerate extended down times or are capable of performing their own hardware repairs.
Short time available for training	Software must be easy to learn -- preferably requiring only a short period of reading. Documentation should still contain reference features and examples, but technical users do not require extensive tutorial material.
Need for technically sophisticated support	Technical users are generally capable of understanding manuals and the overall operation of systems. However, if they need to modify the software or to install it on a new system, they may require support on a highly technical level -- well above that typically provided by most vendors or retailers.

CHAPTER 4 - MICROCOMPUTER APPLICATIONS

As noted previously, microcomputers are general purpose devices which can be used for a variety of tasks. Application software is the single most important component for transforming a general purpose microcomputer into a system for performing such tasks. Table 4-1 shows the most common types of microcomputer application software and indicates where they are discussed in this chapter. Section 4.6 discusses application software for more specialized purposes. Section 4.7 explains how these applications can be put together, i.e. integrated to increase the capabilities of microcomputers beyond those provided by the applications running individually.

TABLE 4-1. TYPES OF APPLICATION SOFTWARE

APPLICATION SOFTWARE TYPE	SECTION WHERE DESCRIBED	PURPOSE
WORD PROCESSING	4.1	Creating, editing, and printing documents
DATA MANAGEMENT	4.2	Organizing, storing, and retrieving data
SPREAD SHEET PROCESSORS	4.3	Performing calculations and formatting for tabular reports (e.g. budget forecasts)
GRAPHICS	4.4	Presentation of data graphs and preparation of diagrams and illustrations
COMMUNICATION	4.5	Data transfer to and from other systems
SPECIALIZED SOFTWARE	4.6	Specialized computation tasks associated with various job functions (e.g. accounting, statistics)

4.1. WORD PROCESSING

Word processing software is used for creating, editing, and printing documents such as memoranda, letters, formal reports, address lists, indices, and contracts. It is particularly useful for repetitive documents (such as form letters) or those assembled from pre-written, standard sections.

The origins of word processing are the text editing programs used by data processing personnel starting in the late 1950s. The actual term was coined with the introduction of the first magnetic card typewriter in 1964. Although slow and limited by present standards, the magnetic card typewriter spurred the development of many similar products over the next five years, and the notion of a "word processing" department began to replace that of the "typing pool". In the early 1970s, word processing systems based on small minicomputers with video screens were introduced. The first word processing system suitable for business and professional use on a general purpose microcomputer was introduced in 1976.

According to a 1981 user survey [ARBO81], word processing is the single most commonly used application on microcomputers. All Government workers who produce documents of any length are potential users of word processing software. Table 4-2 summarizes the applications of word processing software for the four types of Federal users defined in Chapter 3.

Clerical workers spend more than half their working day with documents [TEGE83]. An extended set of editing commands helps to reduce the number of keystrokes and thereby increases productivity. Full format controls are necessary for the production of high quality documents and include features such as flexible pagination, footnotes, proportional spacing, superscripts, and special symbols (e.g. Greek alphabet or mathematical symbols).

Because of the decreasing level of secretarial support provided to many professional and managerial workers in larger organizations [TEGE83], these workers will benefit from software that is easy to learn and use. Unless they are producing long or elaborate documents, a "light duty" package which has limited features but is easy to use is more appropriate than a full-functioned package intended for clerical workers.

Technical users can also benefit from the "light duty" word processing software for much the same reason as professional and administrative workers. For those who spend an extended amount of time in software development, a package which can generate machine readable source code files as well as formatted text files eliminates the need to learn two different sets of editing commands. Low memory usage can be advantageous to workers using word processors in a multitasking environment (e.g. editing software in one task and compiling or running it in another).

TABLE 4-2. USES OF WORD PROCESSING

USER CLASS	APPLICATIONS
CLERICAL	Substitute for standard typewriter
	Production of form letters, address lists, and mailing labels
	Document assembly (i.e. creating a document from pre-written paragraphs or sections stored on disk together with some portions of specially written material. Examples are contracts, RFPs, policy documents, or regulations)
	Production of lengthy documents, formal reports, or camera-ready copy for publications
ADMINISTRA-TIVE	Short letters and internal memoranda
	Preparation of progress reports: may include graphs and tables produced with other application software
	Other light typing to support managerial functions
	Preparation of messages for "electronic mail"
	Composing of rough draft material for longer reports and papers (preparation of subsequent final document by clerical users is easier if the initial draft is created by administrative personnel on a compatible word processor).
PROFESSIONAL	Short letters, internal memoranda, progress reports (similar to administrative users)
	Preparation of professional documents: either in rough form or final copy (depending on typing ability of user and availability of secretarial support). May involve inclusion of graphics and tables.
TECHNICAL	Short letters, internal memoranda, progress reports, professional papers and reports (similar to professional users).
	Preparation of software, software documentation using word processor for traditional text editing functions

Auxiliary packages to aid in the creation formatting, and production of documents include:

Spelling Checkers

Spelling checkers are the most common auxiliary programs. They operate in two phases: (1) the program scans a document and flags words not found in the system dictionary and (2) the user either adds each flagged word to the dictionary or corrects it in the document. Because these programs do not detect misuse of words, proofreading is still required.

Formatting Programs

Formatting programs are a useful supplement for those users who produce large, formal documents (Requests For Proposals, legal briefs, contracts, reports, and papers) or those requiring a good deal of control over the physical appearance of the final copy (e.g. those producing camera-ready copy). These programs read document files that have been prepared with a word processor and produce a printed output. They are controlled by commands which are embedded in the text file when it is created. In addition, some provide a specialized programming language in which a series of formatting commands is invoked whenever a certain event occurs (e.g. at the start of every even numbered page or at the end of each page).

Bibliography Maintenance

Bibliography maintenance programs manage the bibliographic entries associated with a report. References are flagged in the text and the appropriate citations may either be inserted as footnotes or collected into a formatted bibliography at the end of the document.

Grammar and Style Checkers

Grammar and style checkers perform a limited syntactical analysis and scan for "suspicious" (i.e. sexist, stereotypes, or trite) phrases and terms by means of a dictionary. These programs may also search for passive constructions, lengthy or terse sentences, or excessive use of the same structures. Some programs produce statistical summaries of average sentence length, the degree of variation in length, or the number of passive sentences.

Mailing List Programs

Mailing list programs are used to maintain name and address files, but some also have the capability to individualize documents through insertion of a limited number of words and phrases at key points of the document.

4.2. DATA MANAGEMENT SOFTWARE

Data management software (also referred to as "data management systems") is used for entering and retrieving data in formats and orders specified by the user (e.g. alphabetically or chronologically). Information can be retrieved by names, accounts, dates, and a variety of other identifying criteria called "keys".

The basic terms associated with data management software are records, fields, and files. Records can be thought of as the computer representation of a paper form (e.g. application blank, receipt, maintenance request, etc.). The record is made up of fields which can be regarded as analogous to the blanks on the form. A group of records are stored in a file.

Figures 4-1 and 4-2 illustrate the use of a data management system. Figure 4-1a shows a form for recording data on microcomputer procurements announcements from the Commerce Business Daily. The information was entered into records through the data manager and stored in the form shown in figure 4-1b. Figure 4-2 shows a report generated by the data management software from the completed file. The particular package had extensive formatting control which allowed the generation of a 132 column report and a choice of which fields were presented (the reader should note that not all fields on figure 4-1b are shown on figure 4.2).

Table 4-3 defines three broad classifications of microcomputer data management systems. At present, microcomputer based data management systems are not comparable to data base management systems on larger computers because of their limited capacities and their inability to allow more than one user access to a single file. More sophisticated data management applications may be possible through the use of "data base machines" [INTE82, EAGL82] which could be connected to several microcomputers.

Table 4-4 shows some of the applications of data management software. Clerical users can enter data and produce routine reports. However, fewer clerical personnel can be expected to gain the same expertise with data management software as with word processing software. If a long or complex sequence of commands is necessary, the data management software should have a means of storing and executing these sequences without operator intervention (i.e. a data manipulation language).

Administrative applications of data management software include accounting, personnel, inventories, and other tasks which require the retrieval or consolidation of information from paper forms. If relatively simple manipulations are required a card file manager is suitable. More elaborate tasks can be performed with data file managers or a full data base management system.

COMMERCE BUSINESS DAILY ANNOUNCEMENT OF MICROCOMPUTER PROCUREMENTS

DATE: RECORDER:

REFERENCE NO.

FEDERAL SUPPLY CODE HEADING

SYSTEM TYPE

AGENCY

PRIMARY APPLICATION (IF KNOWN)

SECONDARY APPLICATION (IF ANY)

TERTIARY APPLICATION (IF ANY)

SPECIFIED AS BEING PART OF LARGER SYSTEM?

TYPE OF COMMUNICATION CAPABILITY

TYPE OF GRAPHICS CAPABILITY

DBMS SPECIFIED?

BRIEF SYSTEM DESCRIPTION OR OTHER COMMENTS

(a) Form used for recording data

00028	70	1	FISH & WILDIFE SERVICE	4.2	5.2	0.0	F	3	2	2	0	16 BIT MICRO W/ 64K RAM

(b) Representation of data as fields on a record

Figure 4-1. Representation of Data in a File Management System

CONTENTS OF CBD DATA BASE

REF NO	HDG	SYS TYP	AGENCY	APP1	APP2	APP3	PT LG SYS?	COM	NO. PROC	GRFX	DBMS	COMMENTS
8142.01	70	1	N.I.H.	3.0	0.0	0.0	.F.	0	1	0	0	Z89-81(?) MICRO W/ 48K, BASIC
8147.02	70	1	N.O.A.A.	3.0	0.0	0.0	.F.	0	1	0	0	HP-A600
8148.04	70	1	N.O.A.A.	3.0	0.0	0.0	.F.	0	1	0	0	256 KB W/ DISK DRIVE
8155.01	70	1	N.O.A.A.	5.3	0.0	0.0	.F.	0	1	0	0	DATA RECORDER MICROPROCESSOR
8152.03	70	1	NASA	3.0	0.0	0.0	.F.	0	9	1	1	IBM 5150
8138.30	70	2	NASA AMES RESEARCH CTR	5.3	0.0	0.0	.F.	0	1	0	0	HP
8152.07	74	1	NASA JOHNSON SPACE CENTER	5.1	0.0	0.0	.F.	0	1	0	0	HP 9845
8143.04	74	1	NATICK R&D LABS	4.3	0.0	0.0	.F.	0	0	0	0	WORD PROCESSING EQUIP
8156.01	70	1	NATIONAL PARK SERVICE	4.6	0.0	0.0	.F.	0	3	2	1	APPLE II+, III
8143.01	70	1	NATL WEATHER SERVICE	5.2	4.3	0.0	.F.	3	6	3	1	TRS80 W/ MUCH SOFTWARE
8138.34	70	2	NAV AIR DEV CTR	5.1	0.0	0.0	.F.	0	1	0	0	TEKTRONIX 8580 DEV SYSTEM
8151.09	74	1	NAVAL ADMIN COMMAND, IL	4.1	0.0	0.0	.F.	0	24	0	0	COMMODORE BUSINESS MACHINES
8138.39	70	6	NAVAL SUPPLY CENTER	4.3	0.0	0.0	.F.	0	0	0	0	
8138.39	70	6	NAVAL SUPPLY CENTER	4.3	0.0	0.0	.T.	1	1	0	0	WANG OIS 140 SYSTEM
8138.40	70	1	NAVAL SUPPLY CENTER	4.3	0.0	0.0	.T.	1	4	0	0	ADDITIONAL MICROS FOR WANG OIS
8138.41	70	1	NAVAL SUPPLY CENTER	5.7	0.0	0.0	.F.	1	1	0	0	HP 9845B FOR MICROCPTR DEVLPMT
8147.04	70	2	NAVAL SUPPLY CENTER	5.1	0.0	0.0	.F.	0	1	5	1	TEKTRONIX 4054 W/ MANY OPTIONS
8152.02	70	1	NAVAL SUPPLY CENTER	5.1	0.0	0.0	.F.	0	15	0	0	5 EA HP 9826, 9826-1A,9825-4A,
8153.05	70	1	NAVAL SUPPLY CENTER	5.1	0.0	0.0	.T.	1	12	0	0	12 APPLES ON OMNINET
8155.04	74	1	NAVAL SUPPLY CENTER PUGET SD	4.3	0.0	0.0	.T.	1	7	0	0	38 CRTS AT 7 SITES
8145.05	70	1	NAVAL SUPPLY CTR	3.0	0.0	0.0	.F.	0	9	0	0	ZOBEX S11HD12 Z80 (4 MHZ)
8156.08	70	1	NETHERLANDS AIR POLLUTION NET	5.3	0.0	0.0	.T.	2	99	0	0	100 MICROCOMPUTERS
8157.01	70	6	NIOSH ALOSH, W, VA.	4.1	0.0	0.0	.T.	1	7	0	0	7 WKSTAS INCL 2780 COMMUN,
8158.07	70	1	OFFICE OF NAVAL RESEARCH	5.3	0.0	0.0	.T.	0	2	0	0	2 HP 9836A FOR DATA ACQUISITIO
8141.01	70	1	OFFUTT AFB	3.0	0.0	0.0	.T.	2	1	0	0	EAGLE EDP ON CORVUS OMNINET
8151.06	70	6	QUEBEC SUPPLY & SERVICE OFC	4.1	0.0	0.0	.F.	0	13	0	0	9 STANDALONE, 4 SHARED LOGIC
8147.05	70	1	RANDOLPH AFB	3.0	0.0	0.0	.F.	0	3	0	0	128K RAM, LTR QUAL PRINTER
8152.06	70	1	RANDOLPH AFB	5.1	0.0	0.0	.F.	0	36	2	0	8 PLOTTERS, 4 PRINTERS INCL
8153.01	70	1	REED ARMY MEDICAL CENTER	4.3	0.0	0.0	.T.	1	4	0	0	4 WORK STAS, PERIPHS FOR OIS
8153.06	70	1	RICHMOND VA MEDICAL CENTER	3.0	0.0	0.0	.F.	0	1	0	0	COMPUTER TECHNIQUES MODEL 30
8145.01	70	1	ROBBINS AFB	5.1	0.0	0.0	.F.	3	1	0	1	MICRO W/ 512K
8153.08	70	1	ROCKWELL HANFORD OPERATIONS	5.1	0.0	0.0	.F.	0	1	0	1	ONYX C8002 SYSTEM
8157.02	70	1	S.E.C.	4.1	0.0	0.0	.F.	0	1	0	0	APPLICATION NOT SPEC
8151.08	74	1	SOC SEC ADMIN CONTRACTS&GRANTS	4.3	0.0	0.0	.F.	2	4	0	0	DECMATE SYSTEMS
8141.07	70	1	SOCIAL SECURITY ADMINISTRATION	5.7	6.2	0.0	.T.	3	1	3	1	NETWORK TOPOLOGY, TREND ANAL.
8158.01	70	2	SOCIAL SECURITY ADMINISTRATION	3.0	0.0	0.0	.F.	0	1	0	0	FOUR PHASE IV/90
8147.09	74	1	TINKER AFB	4.3	4.7	0.0	.F.	0	1	5	0	CALCOMP 925 PE W/ DRM PLOTTER
8147.10	74	1	TINKER AFB	4.3	0.0	0.0	.F.	0	1	0	0	LEXITRON VT 1303
8147.11	74	2	TINKER AFB	4.3	4.7	0.0	.F.	0	1	1	0	TEKTRONIX COLOR GRAPHICS,HDCPY
8147.12	74	2	TINKER AFB	4.3	0.0	0.0	.F.	0	1	0	0	4 PHASE
8156.05	70	1	TINKER AFB	4.3	0.0	0.0	.F.	0	6	0	0	XEROX 860
8157.05	74	1	TINKER AFB	4.3	0.0	0.0	.F.	0	1	0	0	XEROX 860
8157.06	74	1	TINKER AFB	4.3	0.0	0.0	.F.	0	1	0	0	XEROX 860 (2)
8157.07	74	1	TINKER AFB	4.3	0.0	0.0	.F.	0	2	0	0	2 XEROX 860S
8139.04	70	1	TOOELE ARMY DEPOT	4.3	4.7	4.1	.F.	0	1	0	0	LANIER EZ1, LIST/MERGE, MATH
8152.05	70	1	TOOELE ARMY DEPOT	3.0	0.0	0.0	.F.	0	1	0	0	ONYX 8002 40 MB DISK

Figure 4-2. Report Created by Data Management System from the File Shown in Figure 4-1.

TABLE 4-3 CLASSES OF MICROCOMPUTER-BASED DATA MANAGEMENT SOFTWARE

CLASS	APPLICATION	DESCRIPTION
Card file managers	Small, informal and temporary data files maintained by inexperienced users	Card file managers are the least sophisticated data management software and are generally the easiest to use. They are functionally analogous to a small box of index cards on which the user makes entries. Records consist of fields of limited length. These systems can not perform any arithmetic operations. Operators can enter and edit data and retrieve information by means of key words. Reordering of the records on the basis of alphabetic or numeric values of a specified field may also be possible. Reports produced by card file managers are generally not suitable for formal purposes.
Data file Manager	More formal applications such as periodic reports on personnel and inventory. Useful where more capabilities than Card file managers are needed but where full Data Base Management System is not required.	Data file managers can handle longer records than card file managers, can perform arithmetic operations on the data in the files, and provide the user with greater control over the presentation of data reports. Some file managers also execute sequences of commands (i.e. programs), a feature which simplifies the generation of routine reports.
Data Base Management Systems	Full accounting systems, statistical packages, and other applications involving the use of multiple files and a complex sequence of commands.	The primary difference between data base management systems (DBMS) and the previous classification is the ability to manipulate multiple files simultaneously (a data base can be thought of as consisting of files in the same way that a record consists of fields). DBMS software also can execute programs in the same manner as the more sophisticated data file managers. The language in which these programs are written (i.e. the data manipulation language) may be either the internal language of the DBMS or a more standard high order language (e.g. BASIC or COBOL).

Professional users can benefit from data management software featuring data analysis transcription, and presentation. Data from surveys, samples, or experiments can be stored, retrieved, manipulated, and displayed with relative ease. The data management system can be used to retrieve selected data which are subsequently processed by another program (e.g. a statistical analysis package or an econometric model). Conversely, it is frequently possible to take the data written on a file by another program and convert them to a form usable by the data management software for post-processing. Although most professional users are not expert programmers, they may be capable of using the more powerful data file and data base management software to create applications which significantly increase their productivity and enhance their research capabilities.

Technical users can reap the same benefits as administrative and professional users. An important benefit of data management software is the ease with which record-oriented applications can be created for other users. This benefit is apparent for administrative applications which require data entry, file manipulation, and report writing. Data base management packages contain modules to perform these tasks, and the application programmer need only define the file contents, the specific calculations to be performed, and certain parameters for the report writer. As long as the basic data base does not change, adding additional reports or data entry routines is a relatively simple matter.

TABLE 4-4. USES OF FILE AND DATA BASE MANAGEMENT SOFTWARE

CLASS	APPLICATIONS
CLERICAL	Data entry (if software has provision)
	Generation of routine reports
ADMINISTRATIVE	Accounting
	Inventory
	Project management
	Planning and budgeting
	Personnel applications (smaller scale)
PROFESSIONAL	Maintenance of data files (e.g. questionnaires, chemical analyses on samples, etc.)
	Bibliographies
	Statistical analyses (either directly in the data manager or in conjunction with other software)
TECHNICAL	Development of software for other applications
	Project management and monitoring (similar to administrative users)
	Data files and statistical analyses (similar to professional users)

4.3. SPREAD SHEET PROCESSORS

Spread sheet processors enable a user to define a table, enter data into that table, specify the calculations to be performed on the data, and present the results in a useful format. Figure 4-3 is an example of such a table, which is also referred to as a "model", for a part of an engineering project budget projection. The expected hours for each task were entered, and the spread sheet processor calculated the total hours by job classification (e.g. Technician, Engineer III, etc.) and the cost projections (in another part of the table not shown). Because changes in the number of hours or labor rates in any classification would cause a recalculation of the entire model, the spreadsheet is a useful tool for planning. Management personnel can easily manipulate time allocations to make the project fit within a certain budget or estimate the effect of cost escalations by raising labor rates by a given percentage at the end of each year. Spread Sheet Processors are so named because this process is analogous to the preparation of a "spread sheet" by accounting and management personnel. These programs were conceived of as managerial planning, budgeting, and decision making aids. However, they are also useful for other problems where repeated calculations are necessary.

When VisiCalc, the first spread sheet processor, was introduced in 1979, its purpose was not generally understood [BRIC83]. However, within a period of two years, VisiCalc and its competitors became the most common microcomputer application package for managerial users [MORL82]. A number of authors [FERR82, WOHL82, ROMA83, HIRS83] state that spread sheet processors were the primary motivation for the introduction of microcomputers into large organizations.

There are two general types of spread sheet processors: interactive and non-interactive. Interactive packages perform the specified calculations as the user enters data or defines mathematical operations. Non-interactive packages require the user to create a file which contains all data, commands, and formatting information before the spread sheet results are presented. The primary advantage of interactive packages is the ability to rapidly develop spread sheet applications. In a recent evaluation of three spread sheet processors, Bishop [BISH82] reports development times of 1 and 2 hours for two interactive packages and 8 hours for the non-interactive package. On the other hand, some non-interactive spreadsheet processors use a form of model development which is easier to understand. In addition, because a series of non-interactive models can be run in batch mode (i.e. without operator intervention once execution is started), a user needing to prepare a set of monthly reports based on a relatively small number of inputs can use an editor to prepare the files and can delegate the execution and printout of the models to a less skilled assistant.

Table 4-5 shows possible applications of spread sheet processors for the user classes defined in Chapter 3. Because this software has been oriented toward administrative and professional workers, clerical uses are limited. As was the case with data management software, clerical workers can enter data or generate routine reports if the procedures are well defined and training has been provided. However, such training will probably occur on the job because little clerically oriented training (either material or courses) is available for spread sheet programs.

LABOR DISTRIBUTION BY TASK

	MONTH 13	MONTH 14	MONTH 15	MONTH 16	MONTH 17	MONTH 18	MONTH 19	MONTH 20	MONTH 21	MONTH 22	MONTH 23	MONTH 24	MONTH 25	TASK TOTAL
PROJECT MGMT														
ENGINEER III	30	30	60	30	30	30	30	60	35	35	60	60	60	1000
ENGINEER II	20	20	20	20	20	20	20	20	20	-	-	-	-	340
SUBTOTAL	50	50	80	50	50	50	50	80	55	35	60	60	60	1340
TASK 1														
ENGINEER III	40	40	-	-	-	-	-	-	-	-	-	-	-	360
TECH STAFF	80	80	-	-	-	-	-	-	-	-	-	-	-	720
SUBTOTAL	120	120	-	-	-	-	-	-	-	-	-	-	-	1080
TASK 4.1														
ENGINEER II	-	-	15	15	15	15	-	-	-	-	-	-	-	60
ENGINEER I	-	-	40	40	40	40	-	-	-	-	-	-	-	160
TECHNICIAN	-	-	80	80	80	80	-	-	-	-	-	-	-	320
SUBTOTAL	-	-	135	135	135	135	-	-	-	-	-	-	-	540
TASK 4.2														
ENGINEER II	-	-	15	15	15	15	-	-	-	-	-	-	-	60
ENGINEER I	-	-	20	20	20	20	-	-	-	-	-	-	-	80
TECHNICIAN	-	-	80	80	80	80	-	-	-	-	-	-	-	320
SUBTOTAL	-	-	115	115	115	115	-	-	-	-	-	-	-	460
TASK 5														
ENGINEER III	-	-	-	-	-	-	40	40	40	40	40	50	-	250
TECH STAFF	-	-	-	-	-	-	80	80	80	80	80	100	-	500
ENGINEER I	-	-	-	-	-	-	15	15	15	15	15	25	-	100
SUBTOTAL	-	-	-	-	-	-	135	135	135	135	135	175	-	850
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
MONTHLY TOTAL HOURS	170	170	330	300	300	300	185	215	190	170	195	235	60	7000
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
PERSON HOURS														
ENGINEER III	70	70	60	30	30	30	70	100	75	75	100	110	60	1760
TECH STAFF	80	80	-	-	-	-	80	80	80	80	80	100	-	1720
ENGINEER II	20	20	50	50	50	50	20	20	20	-	-	-	-	620
ENGINEER I	-	-	60	60	60	60	15	15	15	15	15	25	-	1000
TECHNICIAN	-	-	160	160	160	160	-	-	-	-	-	-	-	1600
SR. ENGINEER	-	-	-	-	-	-	-	-	-	-	-	-	-	210
SCIENTIST	-	-	-	-	-	-	-	-	-	-	-	-	-	70

FIGURE 4-3. SAMPLE SPREAD SHEET MODEL

Administrative users can independently develop simple models for planning and budgeting but may need expert assistance for more elaborate models which evolve from their initial work [FERR82]. If the spread sheets are used for accounting purposes or critical decision making, validation or verification of the model is necessary. Checks for correctness within the model (e.g. do all the line items add up to the total allocation?) are a useful means of achieving this result.

Professional and technical workers can use spread sheet processors for simple data operations (e.g. addition, multiplication, some transcendentals). Spread sheet processors are also useful for parametric studies (i.e. the effects of changing input values on the results) on simple models. Technical users can use spread sheet models for both their own purposes and to support the needs of other users.

TABLE 4-5. USES OF SPREAD SHEET PROGRAMS

CLASS	APPLICATIONS
CLERICAL	Data entry and preparation of standard reports
ADMINISTRATIVE	Budgeting
	Project and contract monitoring
	Financial and manpower projections
PROFESSIONAL	Project and cost monitoring (similar to administrative)
	Simple parametric analyses
	Specific calculations amenable to presentation in tabular form
TECHNICAL	Project and cost monitoring, parametric analyses (similar to professional, administrative)
	Preparation of applications for other users

4.4. GRAPHICS SOFTWARE

The increasing capabilities of microcomputer systems and the growing amounts of information which Government workers must handle provide incentives for the use of graphics software. Microcomputer based packages encourage graphics in situations where they have not previously been used because they can be generated rapidly and inexpensively and they are easily modified. Even where the microcomputer generated output is not of adequate quality, it provides good drafts and speeds the production of final copy. Graphics systems can be classified as follows:

Data Display

Display of numerical data generated by other applications or manually entered by the operator is generally handled through the three types of graphs shown in figure 4-4. Bar graphs (4-4a) can be used to display absolute quantities (e.g. the amount of coffee imported from Brazil each year), pie charts are useful for displaying proportions (e.g. the proportions of coffee from South America, Central America, and Africa), and scatter plots are a general means of displaying the relations between two or more variables.

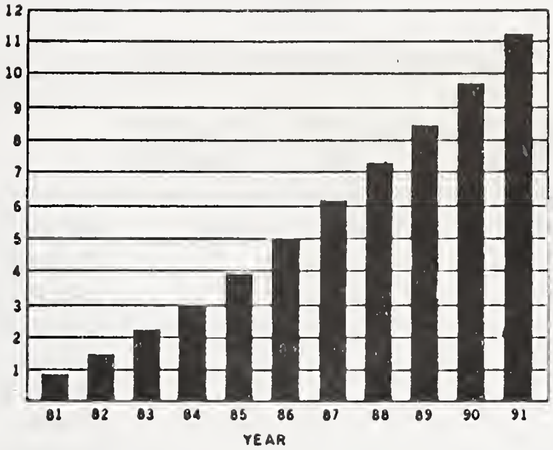
Drawings and Illustrations

In addition to graphs for display of numerical data, microcomputers can also be used to create drawings. Less sophisticated systems can be used to create simple line drawings such as block diagrams, flow charts, or figures created with a digitizer. More sophisticated systems can create complex engineering drawings and manipulate the data to enable computer aided design. Because of their additional hardware requirements, the cost of these latter systems can be several times that of the basic microcomputer.

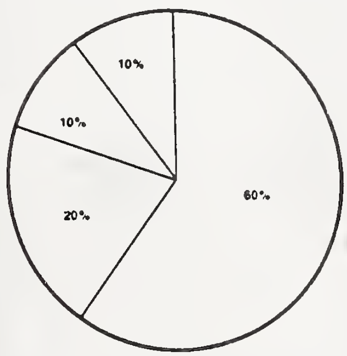
High Resolution Color Graphics

High resolution color graphics represent the most sophisticated level of microcomputer based graphics. They are useful for cartography, medical applications, and specialized technical tasks. This capability requires additional hardware and software which is beyond the scope of most users (at the time of this writing). However, the advent of lower cost memories, color displays, color hard copy devices, and 32-bit microprocessors may bring the cost of high resolution graphics down to acceptable levels in the near future.

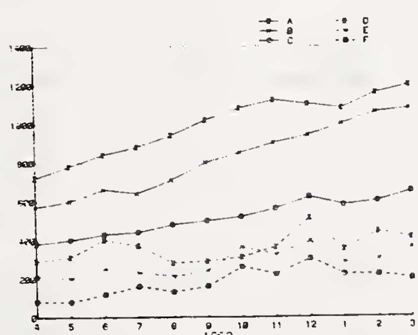
The suitability of a graphics software depends not only on its processing ability but also on the output devices it supports. Available graphics software can produce drawing on printers, plotters, or other devices. Graphics on printers can be produced with either the ASCII character set or with special printer positioning and dot controls. Table 4-6 describes graphics output from common hard copy devices, and figures 4-5 through 4-8 show some examples (Chapter 2 contains a more complete description of the devices themselves).



(a) Bar Chart



(b) Pie Chart



(c) Scatter Plot

Figure 4-4. Types of Graphics for Display of Numerical Data

TABLE 4-6. CHARACTERISTICS OF GRAPHICS HARD COPY OUTPUT

TYPE OF OUTPUT	RELATIVE SPEED	RELATIVE COST	RELATIVE QUALITY	COMMENTS
Character Printer*	High	Low	Low	Major advantage is ability to use ASCII character set -provides greatest flexibility, can be transmitted to other systems, and can be embedded in textual documents (e.g. diagram in instruction manual)
Dot Matrix printer with control over individual dots and precision print head control	Medium-Low	Low	Medium-Low	Dot matrix printer with bit mapped capabilities can produce adequate graphics for informal documents. No standards for non-ASCII matrix patterns, print head control. Thus, no transportability
Fully formed character printer with precision print head control	Low	Medium	Medium-High	Fully formed character printers with precision positioning can produce the same quality lines and symbols as dot matrix printers and can produce higher quality characters. The primary disadvantages are the absence of standard printer positioning controls and the length of time necessary to produce a plot.
Plotter	Low	High-Medium	High	Actually draws the graphics, and is capable of the best quality (depending on driving software). Not efficient where much text is to be included.
Ink jet printers, Laser printers	High	High	High	Costs expected to decrease, reliability, throughput expected to increase as volume increases. Suitable for both text and graphics

* either a fully formed character printer or a dot matrix printer being used without individual dot addressability (see section 2.2)

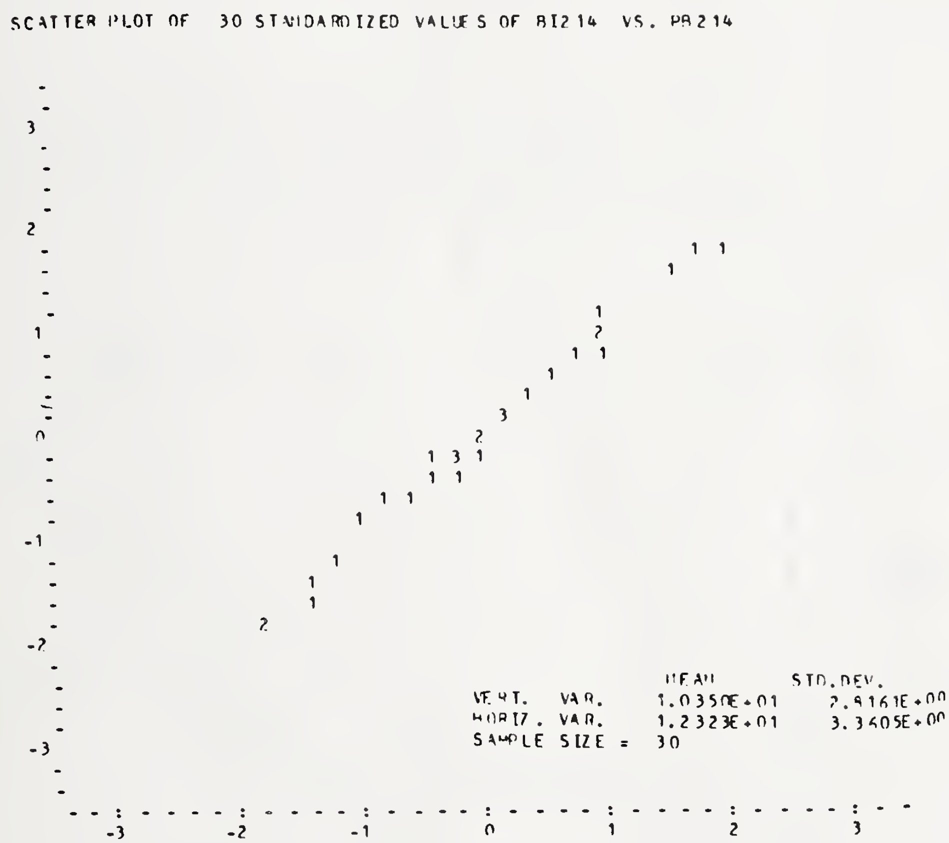


Figure 4-5. Scatter plot produced by a character printer: lines and points are created using symbols from the ASCII character set

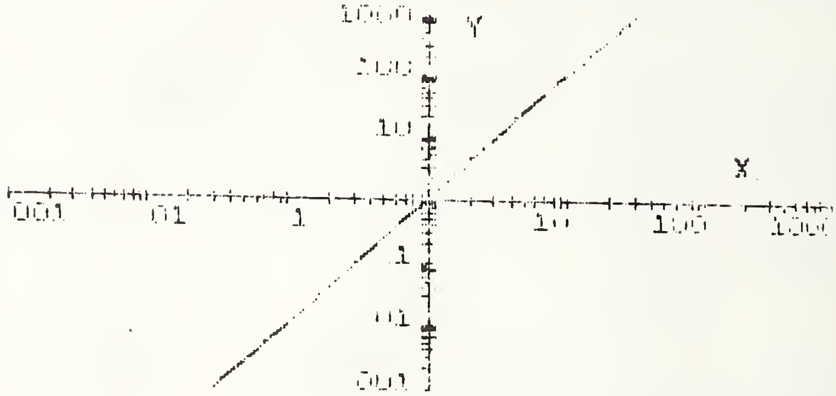


Figure 4-6. Scatter plot produced by dot matrix printer with software controlling each of the dots individually

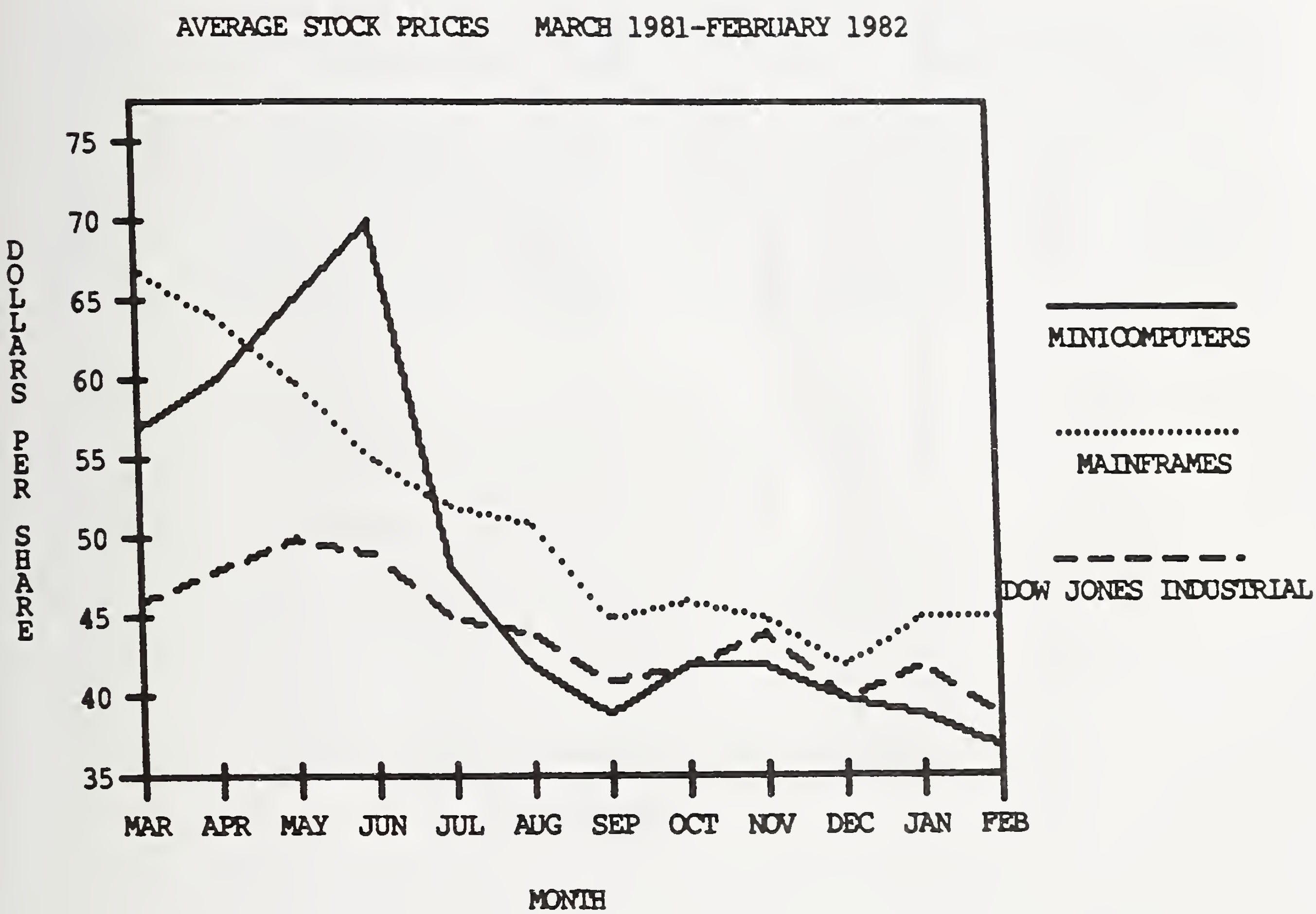


Figure 4-7. Plot Produced by fully formed character printer with precision position control (1/120 " horizontal; 1/48 " vertical)

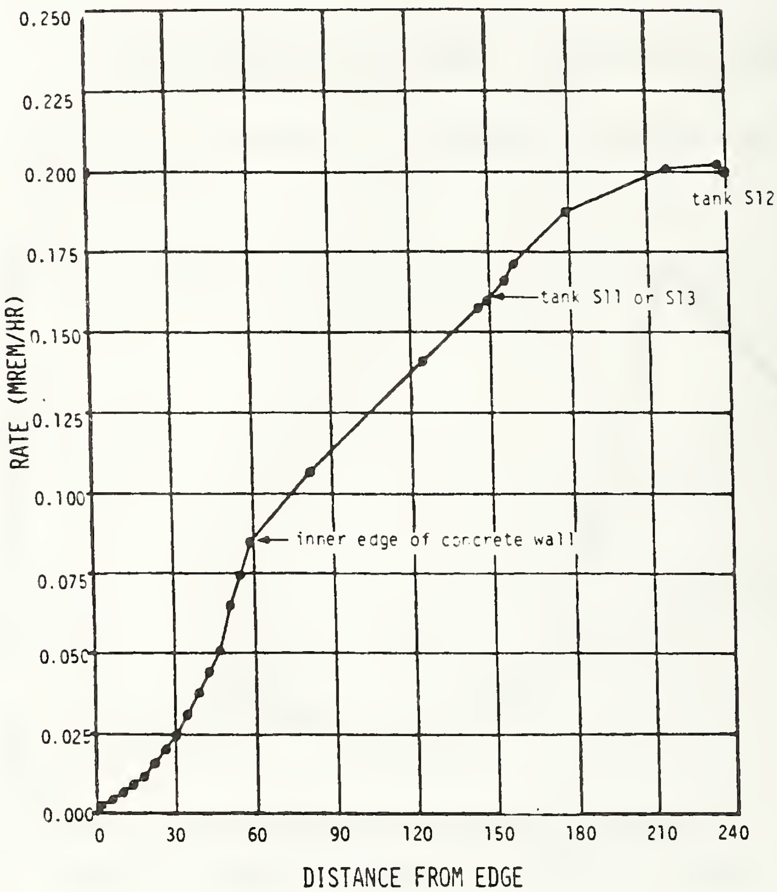


Figure 4-8. Scatter Plot produced by plotter

Ideally, one would like to consider the capabilities of graphics software and hardware devices independently. Unfortunately, standards for graphics have not yet reached the point where this is possible. As a result, graphics capabilities can not be obtained simply by buying the appropriate software, and many users will not find a suitable combination of graphics hardware and software for their system at any price. Major software vendors, the American National Standards Institute (ANSI), and the Association for Computing Machinery (ACM) are attempting to address this problem by offering products or developing standards. However, there are no clear "winners" at this point, and graphics standards remain a controversial and unresolved area.

Table 4-7 shows the uses of graphics software. Clerical workers may use graphics output as part of their document preparation tasks or they may assist users of other classes in the preparation of illustrations or graphs. The primary use of graphics for administrative users is to present data efficiently and to prepare diagrams (e.g. organization charts, project schedules, etc.) for reports and meetings. Professional users may employ graphics for the presentation of experimental data as well as line and bar charts. Technical users have applications similar to those of professional users. In addition, as microcomputer-based CAD systems become more powerful, they may increase the productivity of technical personnel.

TABLE 4-7. GRAPHICS SOFTWARE APPLICATIONS

USER CLASS	APPLICATIONS
CLERICAL	Preparation of charts and graphs based on input supplied by others or generated in the course of the preparation of normal reports.
ADMINISTRATIVE	Graphs for reports, briefings, and other presentations on the financial and management aspects of department, contracts, other areas of responsibility. Graphs are often a more efficient way of presenting information and retaining audience interest. Generation of diagrams for internal use (organization charts, project management schedules and diagrams, etc.).
PROFESSIONAL	Presentation of data generated by user or by other programs.
TECHNICAL	Presentation of data (similar to professional users). Computer aided design. Generation of diagrams for design documentation, reports, presentations.

4.5. MICROCOMPUTER COMMUNICATIONS

Because Government activities require the coordination of the work of many individuals, it is appropriate that microcomputer systems should be linked together. This section discusses communication software and some of the accompanying issues of types of data communications systems.

Microcomputer communication software can be used by all classes of Federal workers as shown in table 4-8. Reliability, performance, and ease of use are important considerations in all user cases. A major use of computer communication for clerical workers is as a replacement for the physical movement of documents. Efficient communication can also enable several people to work on the same document simultaneously even if they are physically separated. The value of this capability may grow in response to pressure for increased clerical productivity.

Teger [TEGE83] points out that the majority of managerial activities relate directly to communication. Thus, managerial and administrative users can benefit from the ability to quickly and easily move messages, data, and documents by means of microcomputers.

The document and data transfer capabilities useful to the previous two classes are also applicable to professional users. These users can perform their mainframe computing tasks using microcomputers and communication software. File transfer capabilities would enable users to perform much of the reduction of the mainframe program printout into a form suitable for interpretation or presentation).

Technical users can benefit from all these capabilities. In addition, they can participate in the dissemination of botn computing-related topics by accessing both public and private research networks. These networks often contain public domain or Government developed software which these users can modify and introduce into their own agencies.

As with all types of computers, data communication with microcomputers involves many technical issues. The Open Systems Interconnection Model of the International Standards Organization [ISO81], currently the dominant framework for the design of computer communications systems, has seven different levels, each of which may have one or more different standards associated with it. Successful data communication requires that the communicating systems be compatible at all levels; attaining this compatibility is generally a complicated and highly specialized task.

However, the field is continuing to develop, and a unified approach to data communications is emerging. One major international effort, the ISO Open System Interconnection Model, was mentioned in the previous paragraph. Another international recommendation, X.25, defines a means of data interchange between systems through a public telephone system. Federal initiatives include the selection of a limited set of options of X.25 to facilitate rapid and efficient data communication [NBS83d] and a standard for exchanging information between computer based message systems [NBS83e].

TABLE 4-8. APPLICATIONS OF COMMUNICATIONS SOFTWARE

USER CLASS	APPLICATION
CLERICAL	Transmission of documents to other sites for hard copy output or review by remote personnel, storage and retrieval of documents from centralized file servers (on local area networks or in conjunction with larger computer installations).
ADMINISTRATIVE	"Electronic mail" (i.e. transmission of memoranda, messages, reports by means of microcomputer communications).
	Transfer of financial and administrative data to and from larger installations.
PROFESSIONAL	Access to data bases on either an internal system or from an information utility or value added network.
	Access to mainframe computer for dumb terminal/ intelligent terminal applications.
	Electronic mail (similar to administrative users).
TECHNICAL	Access to larger computers and computer networks for applications similar to professional users.
	Use as software component in development of distributed computing networks.

Data communication standardization efforts within the Government are described in a recent article [BLAN82]. Readers intending to implement systems are also referred to the "Current List of Documents" from the Systems and Network Architecture Division of ICST [NBS83f].

Section 4.5.1 discusses asynchronous serial communication and section 4.5.2 discusses data communication using telephone lines, a common transmission medium for asynchronous communication. Section 4.5.3 discusses microcomputers as parts of a minicomputer or mainframe-based network, and section 4.5.4 describes local area networks.

4.5.1. Asynchronous Serial Communication

Asynchronous serial communication requires only an RS 232C port or a modem (see section 2.2.8) and is therefore one of the most widely used communication methods. Microcomputer software for asynchronous serial communication software is available for at least the following three general functions:

<u>Teletype emulation</u>

Teletype or "dumb terminal" emulation allows the user to communicate with a remote system as if the microcomputer were a teletype terminal — i.e. to display characters as they are received and to send them as they are typed in. Examples include retrieving news items or responding to electronic mail on a larger remote system.

Teletype emulation requires a minimal amount of processing by the microcomputer, and is the "lowest common denominator" of computer communications. Thus, most mainframe computers and (and computer networks) support this type of communications. However, because all processing and storage must be performed by the host computer (as opposed to the local microcomputer), communication, remote computing, and storage charges can be relatively high.

<u>File transfer</u>

File transfer is the ability of the microcomputer to either send or receive (and store) a file, and is a useful capability for manipulating data either before it is sent or after it is received. Some general purpose file transfer programs require that the files contain only ASCII characters. Where material containing object code or arbitrary symbols is to be transferred, more advanced file transfer programs must be employed.

File transfer is a useful capability for pre or post processing of data. For example, one could use a text editor or word processor to prepare a source program or document file, send the file to the central computer, and then perform additional operations (e.g. compilation and execution or simple printing) at the remote site. Another example is the accessing of financial data contained in files on the mainframe, storing them in a file on the microcomputer, and subsequently manipulating that data with local applications software (e.g. a data file manager for production of a report).

Intelligent Terminal Emulation

Intelligent terminal emulation packages allow a microcomputer to replace proprietary or specialized terminals that have functions beyond those provided by a teletype terminal. This type of emulation processes specialized commands from the remote computer to enable the display of variable intensities, color, or local editing. The integration of a microcomputer into an existing mainframe network may require more than the simple purchase of a software package, and coordination with the central data processing organization is necessary.

4.5.2. Microcomputer Communications Via Telephone Lines

The easiest way to establish a communication link is by means of a telephone and a modem. A modem is a device which converts digital signals to an audio tone sent over telephone lines. Modems may be internal to the computer or externally connected by means of either an RS 232 port (section 2.2.8) or an accoustic coupler. There are three major disadvantages to the use of telephone lines:

(1) Telephone lines are not designed for data communication. Thus, data transmission is slow and not always reliable. The most common data transmission rate is 300 bits per second (approximately 30 characters per second). While such transfer rates are adequate for short messages, a document of 10 pages may require 20 minutes or longer for transmission.

(2) Extensive use of telephonic data communications ties up lines, switches, and equipment needed for voice communication, and can result in excessive telephone charges. If several microcomputers are connected to a single larger installation through telephone lines, specialized devices such as multiplexers or concentrators can be used to reduce the number of lines. However, their use is neither cheap nor always possible.

(3) Establishing a connection between two computers can be an awkward process. The most usual way is to dial a telephone number, wait for a tone from the receiving modem, and initiate data communication. Microcomputer software and hardware capable of automatically establishing contact by means of automatic dialing and log-on are available, but sophisticated telephone communication equipment can easily cost as much as the microcomputer.

These problems make telephone communications less than satisfactory for links where a constant connection is required or a high volume of data is transmitted. Special types of interoffice telephone systems called Private Automated Branch Exchanges, or PABXs are available for overcoming some of these problems in a local setting. However, PABXs are costly, and full utilization of their capabilities requires custom design and technical expertise. Thus, implementation of a PABX may result in a system which costs several times the original purchase price of the microcomputers.

Despite these drawbacks, the low technical risk, adequate performance, and ease of establishing a connection have resulted in telephone lines becoming a popular means of microcomputer communication. The long term prospects for telephone data communications can be judged by the fact that integral modems come either as standard items or readily available accessories for the most widely selling systems.

4.5.3. Microcomputers in Larger Computer Networks

Microcomputers can be incorporated into networks based on a larger computer in a variety of ways. Connections can be established using either telephone lines or connections through the output port of the microcomputer to the larger system (see section 2.2.8). Higher data transfer rates can be established using specialized communication hardware interfaces, specialized software, intermediate communication controllers, and other vendor-specific techniques.

Microcomputer software which emulates teletype or intelligent terminals (section 4.5.1) can be used to establish a minimal level of interaction between the two systems. However, higher levels of integration are beginning to appear. One example is the combination of microcomputers and mainframes for database inquiries [JOHN83b]. The microcomputer provides a "friendly" interface which requests data from the user and formulates a command which can be processed by a mainframe data base management system. Security provisions are addressed either by having the microcomputer provide data on the identity and authorization level of the user making the request to the central system or by having a local determination of access authorization. An even more sophisticated interaction is possible if a microcomputer application package such as a spread sheet analyzer is integrated into the "friendly" interface. This integration allows the user to retrieve and process data without regard to where it resides — i.e. true distributed processing.

Some manufacturers of both mainframe and microcomputers have introduced special adaptations of their microcomputer products that are designed specifically to function in their mainframe computer network. By means of both software and hardware modifications, these units have capabilities which are greater than standard microcomputers with intelligent terminal emulation software. Examples of such capabilities include being able to simultaneously execute microcomputer software while accessing the remote mainframe and the ability to manage several mainframe sessions from a single microcomputer.

The close coordination of microcomputers and mainframes raises a number of management problems. Uninhibited access to the central mainframe can result in an excessive load. Concerns of data validity, integrity, and security are much greater when users have both easy access to central agency data and the ability to manipulate it using microcomputer applications which have not been validated and approved by the central data processing entity. Finally, if microcomputer procurements have been made without regard to the possibility of integration, it may be technically difficult or impossible to achieve the levels of performance and reliability necessary to implement distributed processing.

4.5.4. Microcomputers in Local Area Networks

Local area networks consist of devices interconnected by high-speed short distance lines. Among the potential benefits of local area networks are the sharing of expensive peripherals, the facilitation of communication among microcomputers, and the integration of microcomputers with minicomputers and other types of office automation products. Local area networks vary in performance and cost. The least expensive networks can be implemented at approximately $500 per node (i.e. microcomputer or peripheral) while more powerful systems can cost ten times as much [EISE83]. At least 40 firms were active in local area networks at the end of 1982 [SMEJ82, HUGH82]. However, the number of firms with viable products, support, and distribution is probably much smaller. One recent article [FOST83b] cites an expert who feels there are only two practical microcomputer-based local area networks.

Lower priced systems are available with transmission rates of 1-2 megabits per second, and supporting software may allow the sharing of a hard disk. High performance systems use rates of approximately 10 megabits per second, and software support includes electronic mail and support for sophisticated printers, long-haul communication devices (generally using asynchronous serial communication over telephone lines), and mass storage devices.

Local area networks (LANs) can be characterized in a number of different ways. Two commonly used characteristics are <u>topology</u> and <u>communications</u> <u>medium</u>.

The <u>topology</u> refers to the manner in which they are connected. Figure 4-9 shows three common topologies available in current local area network products. The star facilitates the sharing of resources such as hard disks, communications devices, printers, or common data files which are located at the central node. Two popular microcomputer-based local area networks use this topology [EISE83, SAAL83] which is appropriate as a small and low cost means of implementing a network. However, because traffic is limited by the throughput of the central node which is in turn limited by cost constraints, such a topology is not optimal for a large number of nodes.

The linear bus topology is also useful for sharing devices as well as facilitating communication between any of the nodes. The linear bus has been standardized on 4 levels of the ISO reference model [ISO81] as IEEE Standards 802.3 and 802.4 [IEEE83a, IEEE83b]. Because of its developmental and commercial history, the linear bus has become increasingly important for medium and large sized local area networks.

At present, the ring topology is not as prevalent as the star and linear bus but has been used in process control applications together with the token passing access method. In this application, each member of the network gets access to the communication channel (i.e. the <u>token</u>) for a set time at predefined intervals). Standardization for ring-based local area networks using token passing is currently in progress as IEEE P802.5.

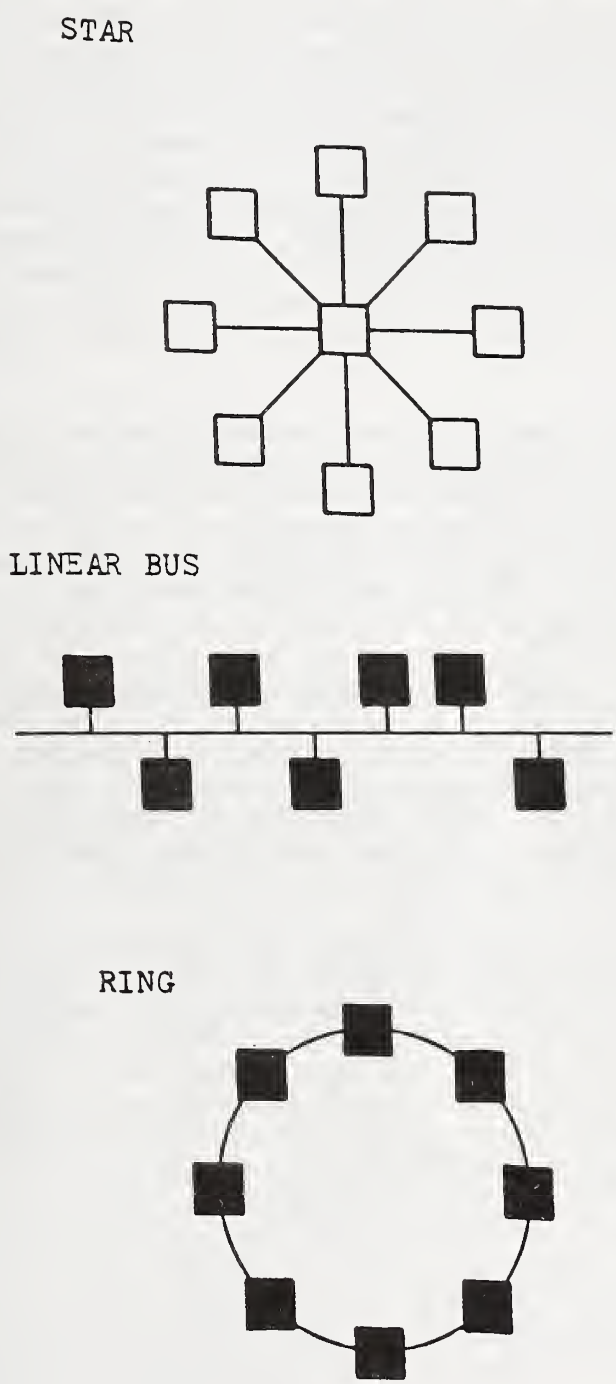


Figure 4-9. Topologies for Local Area Networks

The communications medium describes the nature of the links between nodes. Lower performance systems use "twisted pair" links, i.e. copper wire and connections similar to the RS-232 (section 2.2.8) standards. The advantages of this medium are low cost and the ease of connecting and disconnecting devices. Higher performance systems use coaxial cable and radio-frequency type communications. Two types of transmission techniques are available over coaxial cable: "baseband", in which all devices share a single communication channel and "broadband", in which devices can communicate with each other on dedicated frequencies (some broadband networks have a baseband channel). Optical fibers, the newest communication link, allow the highest data transfer rates and solve many of the problems associated with electrical signals (power surges, radio frequency interference from electric motors, etc.). However, it is the most difficult and expensive communications medium to install, and is still somewhat experimental.

In addition to the general type of network to which the microcomputer will be attached, there are additional issues associated with the software support. For example, one of the most common motivations for using a LAN is resource sharing. One such resource is a mass storage device (a "file server"). In some current systems, the file server is nothing more than a hard disk drive with a controller to prevent several users from accessing it simultaneously. Each user has an independent directory, and no provisions are made for file sharing. More sophisticated file server software allows for the accessing of a single file by multiple users with access controlled by means of a password system. A still higher level of sophistication would allow simultaneous access to a given file (e.g. for data entries and queries from multiple operators). If the network architecture allows for the inclusion of a minicomputer as a file server, other functions at these higher levels might provide for some form of distributed processing for software development (e.g. compilation on the central device while editing is performed locally).

Local area networks are a topic in and of themselves, and a complete discussion of the issues involved is beyond the scope of this report. An NBS publication [NBS82] contains a more complete exposition of this subject. Protocol and physical interfaces of local area networks are currently in the process of being standardized under the IEEE Project 802. In addition to the 802.3, 802.4, and 802.5 standards which were noted above, work is under way on a metropolitan area network (802.6) as well as an overall architecture (802.1) and logical link control protocol (802.2).

4.6. SPECIALIZED SOFTWARE

Specialized software includes application packages not covered in the previous sections. Traditionally, these specialized programs have been written by the end user (or programmers employed by the end user) because of the small number of installations with the same hardware and software, a fact which inhibited the development of third party software. However, the advent of microcomputers changed this situation, and many specialized software packages are currently available for purchase. In addition, other microcomputer software such as data base management systems or spread sheet analyzers can be used to construct applications. Custom software development is also an option for unique applications.

Purchased Software

Although applications such as project management, capital assets management, or electronic design are of less general interest than word processing, packages have been developed for these purposes. Unfortunately, they are not as readily available as the more standard types of applications and are often more expensive. Despite these difficulties, specialized software packages can significantly increase the productivity of specialists working in these areas, and the cost is frequently recovered within a short time after their purchase.

Data Base Management Systems and Spread Sheet Analyzers

Users who cannot find software for their application should first consider a data base management system or spread sheet analyzer before embarking on a software development effort in a more traditional computer language. Their generality has enabled these software products to be extended beyond their original intended applications. These programs have been used for accounting, statistics, cost estimation, project management, and real estate calculations. Even if the generic applications do not provide adequate capacity over the long run, they can serve as a guide and specification to the developers implementing the final product.

Custom Programming

In cases where software meeting the needs of end users is not available, custom programming may be the only alternative. This is the most costly and uncertain option and should not be undertaken without expert assistance in both management and development. These efforts are also appropriate if the product will be used on many systems. In other cases, the software development aids, utilities, and the experience base on larger systems may favor the development of the application on a minicomputer or a mainframe.

4.7. APPLICATION INTEGRATION

The previous sections described how applications can be useful to Federal workers as stand-alone programs. However, if these programs can be integrated, i.e. made to work together, microcomputers can provide greater benefits. For example, a formal report containing textual material, numerical data, and graphics prepared on a microcomputer requires a word processor, spread sheet analyzer, and graphics program. Changes in the data would require that the user re-execute all three programs and reassemble the document. However, if the applications were integrated, users would make only a single set of corrections to the spread sheet model, re-execute the integrated program, and produce the final document. Table 4-9 lists some of the benefits of integration.

Integration can be achieved through common file structures, integrated programs, multitasking operating systems, and application environments.

File Compatibility

File compatibility means that one application can read and manipulate the file of another. In the example cited above, the word processor and graphics program can read files produced by the spread sheet analyzer. If the change in the example given above were made in a system with compatible files, the user would only make changes in the spread sheet program, and incorporate the results into the other applications.

Because of the ASCII standard, compatibility of files containing only characters is not a problem. Thus, the file-level integration of character oriented applications such as word processing or data management is generally possible. However, file compatibility is more difficult for spread sheet and graphics software. There is no current standard for representing graphs and spread sheets (i.e. the calculation rules and the floating point numbers) which is generally accepted, although a number have been proposed (e.g. [SOFT80]). The most practical solution for this level of integration is the use of "companion" packages, i.e. a set of application software which can process the files of other software in the same product line. The disadvantage of this approach is that users do not have the flexibility to choose the best application in each area. Once they have chosen the first package, they are committed to the rest of the product line.

Integrated Packages

Integrated packages contain several applications in a single software product. Integrated packages are easier to use than separate file compatible software when several applications are being used for a given task. Changes such as those presented in the above example could be accomplished without having to execute applications individually and then return to the operating system.

One major disadvantage of integrated packages is similar to that of the companion software packages: the user is committed to a single set of applications -- one or more of which may be inadequate. A second

disadvantage is that the files produced by integrated packages may not be file compatible with any other software even if the data files contain only alphanumeric characters (i.e. word processors and data managers). Thus, unless the integrated packages produce ASCII files (or the user is sufficiently knowledgeable to create them by means of operating system utilities), the output of the integrated packages can not be transmitted to other systems or used by other software.

Single-user Multitasking Operating Systems

Single user multitasking operating systems combine the advantages of file compatible software with the ease of use of integrated packages. Because multitasking systems allow the "simultaneous" execution of a number of tasks, users can keep several applications in RAM and move between them by means of a simple keystroke rather than a series of commands to exit from one application before starting up another. A major advantage of this approach is a greater choice of individual applications which alleviates the problems of being constrained to a single product line. Disadvantages include the substantial hardware requirements of multitasking operating systems and the difficulty of learning how to "juggle" several applications simultaneously, a problem which may preclude this approach for less sophisticated users.

Application Environments

Application environments are elaborate user interface programs which work in conjunction with the operating system to provide users with the ability to control several applications simultaneously. These interfaces make the transitions between tasks easier than multitasking operating systems for unsophisticated users.

A significant advantage of application environments is that their developers have defined file structures which overcome some of the problems noted earlier. Thus, graphics can be placed in the middle of a text file and transmitted to other systems (if they are equipped with the same environments). Some of the major software vendors who sell these packages have stated their intention to encourage independent programmers to develop applications in the same manner as operating systems. Thus, these environments may eventually provide users with a wide range of choices of mutually compatible applications. However, current software offerings for most application environments consist of a single line of products with the same disadvantages noted above.

TABLE 4-9. APPLICATION INTEGRATION

APPLICATION	BENEFITS
Word Processing/ Data Management	Incorporate reports generated by DBMS Management into documents produced with a word processor.
Word Processing/ Spread Sheet	Incorporate spread sheet calculations (either total or partial) into reports, memoranda, and other documents produced with a word processor.
Word Processing/ Graphics	Incorporate graphs into reports and other documents. Note: suitable only where single output device produces adequate quality of both text and graphics.
Word Processing/ Specialized Application	Incorporate results of specialized applications directly into documents under preparation without need to retype.
Data Management/ Graphics	Plot (bar, pie, scatter, other) data in selected (or all) records.
Data Management/ Communication	Transmit (or receive) data for inclusion in files.
Data Management/ Specialized Application	Entry, maintenance, modification, searching, sorting of data records can be handled by file manager, actual specialized analysis performed by other application programs (either written in data manipulation language of DBMS or as separate program in other HOL).

TABLE 4-9 (continued). APPLICATION INTEGRATION

APPLICATION	BENEFITS
Spread Sheet/ Graphics	Presentation of spread sheet results in an easily understood form. This capability is useful when dealing with larger tables or when presenting results to others less involved with the details of the calculations.
Spread Sheet/ Communication	The ability to transmit spread sheet results or take data from larger systems (e.g. economic data from public access computer networks) for use with a spread sheet model.
Spread Sheet/ Specialized Application	Ability to take results of specialized program (e.g. solution to a set of partial differential equations) and perform simple parametric studies on results without need to rerun a complex application.
Graphics/ Communication	Transmission of graphic material to other users. Note: alternative for data plots is transmission of numerical data in ASCII format and replotting at remote site. However, for diagrams, designs, and other non-data oriented graphics, this may not be practical.
Graphics/ Specialized Application	Direct plotting of results of specialized application.

CHAPTER 5 - MANAGEMENT ISSUES OF MICROCOMPUTERS

This chapter discusses several topics on microcomputer usage and management. Section 5.1 discusses the motivation for the use of microcomputers and their utility to the four user classes described in Chapter 3. Section 5.2 lists factors affecting the costs of microcomputers, 5.3 discusses the risks in their use, and 5.4 describes some of the means of avoiding or reducing theses risks. Finally, section 5.5 lists currently available sources of microcomputers available to Federal users.

5.1. MOTIVATION FOR USING MICROCOMPUTERS

The demand for microcomputers in the United States is large and growing. A major financial periodical [BUSW82] estimates the combined 1982 sales of the four market leaders at $5.5 billion (including microcomputer hardware, software, and subsidiary products). Estimates of 1982 shipments of personal computers vary from 860,000 to 2 million (depending on whether home or entertainment systems are included) and a 500% increase is predicted by 1986 [DODG82]. Microcomputer usage in large organizations is growing even faster than the general market. Most researchers predict that government and corporate demand for microcomputers will equal or exceed the rest of the market by 1986 [DODG82].

A driving force behind this rising demand is the need to increase the productivity of white collar workers who now make up approximately one half of the United States workforce [TEGE83]. One study quoted by Goldfield [GOLD83] estimated the productivity gain of this sector at 5% over the last decade while the corresponding increase for industrial productivity was 83%. The Federal government has even more motivation to use microcomputers. According to a recent General Accounting Office study [GAO82], white collar workers comprised 80% of the Federal work force and cost $81 billion in 1980.

Table 5-1 shows examples of how microcomputers can be applied to the tasks of Federal workers. The low cost of hardware and standard software applications and the fast response possible with microcomputers (especially for highly interactive tasks) make them promising vehicles for increasing worker productivity in a variety of functions.

In addition to individual productivity gains, microcomputer installations can provide more global benefits to agencies. Some of these include:

> an increased level of operational reliability where compatible systems are installed. Work can be moved to another computer if one system fails
>
> joint development and sharing of applications
>
> gradual updating of inappropriate or obsolete equipment (updating of a central computing facility is always a high risk activity)

It is therefore not surprising that some Federal agencies have begun to procure microcomputers in quantities of hundreds or thousands, and that these systems now constitute a significant portion of Federal computer procurements.

In August, 1982, 45% of the data processing announcements in the Commerce Business Daily, the most comprehensive single source of Government procurement activity, were for microcomputers and an additional 27% were for minicomputers whose performance capabilities were in the range of contemporary microcomputer systems. Because of their low unit prices, many microcomputer purchases were not opened to competitive bidding (this practice is allowed under current Federal ADP procurement regulations). Thus, the level of purchases is probably even higher than suggested by these figures.

TABLE 5-1. APPLICATIONS OF MICROCOMPUTERS TO CLASSES OF USERS

CLASS	APPLICATIONS
CLERICAL	Document preparation Data entry Preparation of routine budget and fiscal reports
ADMINISTRATIVE	Document preparation Planning and budgeting Contracts administration Personnel administration Graphics for meetings and presentations
PROFESSIONAL	Document preparation Bibliographies Data management Statistical and profession-specific calculations Graphics for reports and presentations Laboratory automation Terminal emulation (for interaction with larger computers) Other specialized applications
TECHNICAL	Software development and validation Laboratory automation Computer communication Automated testing and data collection Terminal emulation Document preparation Bibliographies Data management Other specialized applications

5.2. COSTS OF MICROCOMPUTER SYSTEMS

Although the cost of the microcomputer hardware and software is relatively low, the cost of effective implementation in a large organization can be much higher. The system costs start at the time the procurement is initiated and continue throughout its life. Major cost components include hardware, software, procurement, site preparation, installation and implementation, training, supplies, maintenance, and communications. Table 5-2 describes these components in greater detail. It is quite reasonable to expect that the total cost of the system will be several times that of the initial hardware and software costs.

TABLE 5-2. MICROCOMPUTER COST FACTORS

CLASS	ITEMS
Procurement	Requirements specification Consultations Purchasing process (include preparation of RFP and evaluation of bids if relevant)
Hardware	Basic System (CPU, memory, disk drives) CRT terminal(s) Additional disk drives (e.g. hard disk) Printer(s) (dot matrix and letter quality) Modem Attachments and accessories (additional RAM, interfaces, cables, etc.) Additional peripherals (plotters, joysticks, digitizers, etc.) Specialized interfacing costs (consider when adding any serial device) Furniture (CRT tables, chairs, printing stands, etc.) Noise Hoods Electrical power conditioning equipment and battery backup units (as required)
Software	Operating system(s) Purchased application software Software installation and modification Custom developed packages Cost of updates Ongoing software support costs

(more)

TABLE 5-2 (continued). MICROCOMPUTER COST FACTORS

CLASS	ITEMS
Site Preparation	Air conditioning Electrical work Installation of Cables Alteration of offices and work areas (including carpentry work) Lighting changes (desk lights, curtains, etc.) Lost production time during site preparation
Conversion	Inputting data to new system Modifying (or rewriting) programs Setting up files Managing conversion effort
Implementation and Installation	Lost production time during installation Cost of running parallel operations Planning and supervising costs Freight Charges Keeping track of the location of all hardware and software components
Training	Cost of training and supplemental materials not included with package purchases Lost production during training Cost of providing space for on-site training "Refresher" courses and ongoing training for new employees
Supplies	Disks Paper Ribbons Anti-static mats and sprays Cleaning supplies Glare screens Paper stands
Maintenance	Cost of maintenance contracts (if available) Cost of transporting systems to repair depot (if on site service is not provided) Cost of spare units Lost production time Lost production data
Communications	Telephone charges Cost of components (cable, interfaces, software) Cost of network installation Outside network charges

5.3. RISKS OF MICROCOMPUTERS

Microcomputers create two types of risks: technical and organizational. Technical risks are related to the inability of the system to function according to expectations. Organizational risks arise because of the problems in implementing and managing microcomputers in large organizations.

5.3.1. Technical Risks

The technical risks of microcomputers can result in both total failures and inadequate implementations. Although these problems also affect larger computer systems, microcomputers are unique because they are installed in large numbers and in settings where expert support is not readily available. The failure of microcomputers to deliver the expected performance can be due to any combination of the following causes:

Improper Specifications or Requirements

The most obvious reason for a system to fail to live up to expectations is that users did not specify exactly what performance was expected. Requirements and resultant specifications must consider issues ranging from organizational policies to the placement of electrical outlets, and must be understood by all those involved with the system. In larger and more expensive computers, generation of functional requirements and systems specifications is an important part of a long computer selection process and is performed by knowledgeable personnel. However, the low prices of microcomputers make such a process more difficult to justify economically despite the fact that it is still necessary.

Less Capable Vendors

Low profit margins and high volume have limited the ability of vendors to provide the required level of technical competence for microcomputer sales personnel. The high rate of innovation exacerbates this problem because no time is available to orient or train the sales force for each new product. These circumstances have resulted in a greater frequency of misunderstood specifications, product misrepresentations, and inadequate post-sale support.

Less Technically Knowledgeable Users

The proliferation of microcomputer hardware and software has not been accompanied by a corresponding increase in the number of technically qualified personnel. As a result, the ability of Federal users to resolve system problems is limited. Areas of particular concern include multivendor systems, communications, software installation, and customized applications. The only way to resolve these difficulties may be to discard an entire system.

Hardware Reliability

Although the entrance of major computer manufacturers into the microcomputer market resulted in the establishment of a higher standard for manufacturing quality and hardware reliability, users may still face the possibility of getting an unreliable and unmaintainable system. A way to reduce this risk is to procure systems from qualified suppliers and major manufacturers.

Software Problems

Problems in software may arise from incompatibility with hardware or other installed software, programs not meeting user expectations, or poorly written code. Because of widely used operating systems, microcomputers may actually offer users better protection than larger systems for standard applications (i.e. word processing, spread sheets, data management, graphics, and communications): unsuitable software can simply be replaced with a competing product. Unfortunately, these problems can not be so easily resolved in specialized applications and custom developed code. The scarcity of qualified microcomputer software experts coupled with the relatively limited software development and debugging tools available for microcomputers contribute to the problem.

Interfacing Problems

The difficulties of connecting peripheral devices such as printers, plotters, and pointing devices to "standard" ports has been discussed in Chapter 2. Microcomputer users are particularly vulnerable because multivendor systems are quite common. As was the case in software and hardware related problems, the relatively low level of expertise that can be brought to bear on an individual system is often insufficient to solve the problem.

As was noted in Chapter 5, establishing communication links between a microcomputer and other computers can also pose problems. Difficulties can arise on the hardware level, the software level, or both, and their resolution can be both time consuming and costly.

5.3.2. Organizational Risks

Even if microcomputer installations are satisfactory from the individual user's point of view, they can pose a risk to the organization as a whole. Most of the issues relate to control over information resources within the organization. However, there are additional concerns over mastering the new technology and the change in the nature of the centralized computing function. The following is a partial list of risks which agencies may face while implementing microcomputers:

Uncontrolled proliferation of microcomputers

The presence of a large number of incompatible microcomputers within a single organization presents an unmanageable situation to those

responsible for maintenance, training, and support. The problem may be exacerbated if there is a need to interconnect these systems to internal minicomputers or mainframes.

Unfortunately, the adoption of organizational guidelines and policies addressed at resolving this problem is not risk-free. A poor choice of computers and the way in which they are interconnected could freeze an entire organization into an obsolete technology. A mandatory standard microcomputer system may be such a poor fit to the needs of a significant number of users that their ability to perform their tasks is impeded. Conversely, a standard system may be overly elaborate and thus a wasteful investment.

Loss of control over data

The growth of microcomputer use complicates the control over generation and disposition of machine readable data. This issue may actually preclude the use of microcomputers in agencies dealing with confidential or sensitive information. Even if the data being used on the microcomputers are not so critical, end users may not understand the need to back up files and validate their data.

Data in Federal agencies are subject to acts of Congress (e.g. Brooks Act, Freedom of Information Act, and the Paperwork Reduction Act,) and rules issued by the General Accounting Office and the Office of Management and Budget [GAO82]. Agencies must comply with these regulations in order to ensure the integrity and security of data collected and generated by the Government [BRAI83]. If all records are in the hands of the end user in the form of (erasable) magnetic media, there can be no central access to that information and no audit trail of what was done.

Loss of control over programs

Two problems concerning software usage on microcomputers are unauthorized duplication and undocumented and unvalidated user-generated applications. The presence of compatible systems makes software interchange both necessary and desirable. However, it also facilitates the generation of copies for use on systems other than those for which the software was licensed. The legal liabilities of such activities have not yet been definitively determined. However, at the very least, agencies would probably have to pay for all unlicensed copies, an unanticipated expenditure which can severely limit system growth plans.

Undocumented applications are useful only to the author. Their future value is lost. Applications used for accounting purposes or for making important decisions should be validated. Unfortunately, the need or procedures for such validation may not be understood by the program writers and users.

<u>Tension between Microcomputer Users and the centralized computing facility</u>

The diffusion of control over information resources from a centralized department to individual users will cause a number of changes. Programmers and analysts who formerly worked on mainframes may have to start supporting microcomputers with a resultant need to undergo retraining and a new period of learning. In addition, microcomputers may compete with other data processing resources for budget and manpower allocations within the organization. Widespread installation of microcomputers could reduce demand for some types of data processing services offered by the centralized department. This problem has received increasing attention by a number of authors [STJO82, DODG82, DODG83, FERR82, HOUS82, CORT82, OHAR82, BLAN83].

5.4. PREVENTION OF PROBLEMS

Preventing the problems listed in the previous section implies a recognition of the risks and explicit actions to reduce or avoid them. Among the actions that an agency can take are the institution of microcomputer policies, support provisions, maintenance planning, and development of a training program. These topics are discussed in this section.

5.4.1. Microcomputer Policies

The primary goal of using microcomputers in an agency is to further its organizational goals. Microcomputer implementation policies embody the strategies for achieving this goal. These policies could, but do not have to, suit the interests of individual users, but the user community as a whole should benefit from policies which complement the overall mission of the organization. The degrees of latitude in these policies may range from those which encourage the installation of many different types of systems to those which severely restrict the freedom of prospective purchases to a single vendor. Agencies with sharply differentiated applications and technically capable personnel may have policies which encourage experimentation with a variety of systems; those with limited resources and more uniform applications may wish to enforce a more restricted policy.

Areas which should be addressed in the organizational microcomputer implementation policy include:

Standards for common interfaces, operating systems, processors, languages, data formats, and other compatibility-related areas

System architectures (i.e. computers and the ways in which they are interconnected) that allow for growth at the individual user level and across an organization to support shared resources, multiple user networks, and new technologies

Leverage of volume purchases to obtain preferential support from vendors

Internal support to assist users with problems and to reduce duplication of efforts.

A good policy will allow for flexibility to meet changing organizational requirements, growth of demand, and the fast pace of technological innovation. From the user perspective, good organizational policies would ensure a consistent, high level of support and clear procedures for obtaining approval of proposed installations.

The implementation of a microcomputer policy should fit the operating style of the organization. Thus, it can range from an informal system of giving advice to users to formal controls with technical and consulting support. In a small or highly decentralized agency with no resources to provide support, informal advice to users may be the only feasible policy. In larger or more centralized organizations, specific individuals can be designated to implement a policy that includes selection guidelines, recommended vendors, standards, and compliance incentives. In extreme cases where tight central control over the use of information and systems is essential, a control function can be set up to oversee and support all installations.

5.4.2. Support Provisions

Users of microcomputers may need a variety of types of support ranging from simple help in the physical installation of equipment to technical and analytical support in creating complex applications. Some users are sufficiently knowledgeable to work without any support; others may require extensive training and ongoing assistance. Federal agencies can choose to provide some or all of the required support internally, they can depend on the systems' vendors, or they can turn to third parties such as consultants. Smaller organizations may not be capable of providing support because of both staffing and cost considerations; larger organizations may already have support staffs established which could add microcomputers to their responsibilities. Because of their ongoing activities in support of other customers, responsible vendors may be more capable of responding to intermittent requests for assistance. Special requirements such as remote installations, an unusual application, or one-time group training may be best handled by consultants, who can provide a higher level of support for specialized applications.

The support needs of microcomputer users can vary substantially with the applications. Systems that are brought in for basic stand alone applications (e.g. light typing or spread sheet-type problems) will result in relatively light demands on the organization. However, the use of a specialized internally developed program (e.g. a custom tax package for tax auditors) causes much greater demand on the organization both in the implementation and maintenance. As a result more support and control may be required.

5.4.3. Hardware Maintenance and Repair Planning

Planning for microcomputer maintenance is necessary in order to minimize down time and the resultant significant losses in productivity. Two major choices

involved in hardware maintenance and repair planning are where to perform the repairs and by whom the repairs should be done.

Possible repair locations include the site at which the systems are installed, a local service location, and a remote service location. On site repairs require that the service technician have an adequate supply of spare parts, test equipment, and tools at either the site or rapidly accessible location. Local service centers require that the system be brought in for repairs; central service centers require that the equipment be shipped to a distant location.

The actual repairs can be done by an employee of the user organization, the vendor, or third party repair service. When the user organization takes the responsibility for maintenance, they take on the whole complex set of problems of running a repair service which includes maintaining inventories of parts, test facilities, and keeping an adequate staff. The greater the range of systems to be supported, the more complex the service requirements.

Factory service technicians may be the most straightforward method of providing support; where warranties are involved, the vendor may require all service to be done by factory authorized personnel. Use of factory personnel may not be possible if the equipment is purchased from a smaller or newer company which does not support equipment at distant locations. Generally, service personnel from hardware vendors only service their own equipment. Thus, multivendor systems are often difficult to service by means of factory personnel.

Third party repair organizations can range from a single person working in the back of a computer retail shop to a nationwide organization able to service a wide range of equipment brand names and types. This may be the best way to handle multivendor systems. However, as with internal repairs, warranties may be voided.

Additional issues concerned with hardware repair include hours (typically 8-5 Monday through Friday), charges for off-hour service, guaranteed response time and repair time, replacement of an entire system if repeated repairs are unsuccessful, loaner systems for use while repairs are being made, and the stockpiling of backup systems. In general, the more critical the system, the more service is required.

5.4.4. Training

Training is often necessary to enable users to gain the full benefit of their systems and applications. Even if users are capable of reading and understanding the documentation accompanying their systems, training can frequently be economically justified by shortening the learning period and conveying information which may not be contained in the documentation. Training can be provided by the vendor or the user organization in any of the following ways:

Self-paced instruction manual

Computer assisted instruction

Audio and/or video tapes

Class Instruction

Individualized Instruction.

In general, the cost of training increases in the order listed above. The effectiveness of any of these methods depends on the quality of the instruction and material, the skill base of the trainee, the complexity of the package, and the application requirements. The amount of time devoted to training depends on projected use of the system or software package. If a user intends to rely on a particular system as a key tool in doing daily work, then a substantial commitment of time to training may be warranted.

Other factors to be considered in the development of a training program include availability to users in remote locations, hours available (swing and night shift employees may not be able to come in during the day), validation of success with provisions for follow up of in problem areas, advanced skills training, ongoing trouble shooting, and special application training.

5.5. SOURCES OF MICROCOMPUTERS

This section describes sources of microcomputers available to Federal users. Section 5.5.1 describes microcomputer procurement through the General Services Administration. Section 5.5.2 discusses procurement through the internal entities of Federal agencies, and section 5.5.3 discusses external sources of microcomputers.

5.5.1. The General Services Administration

The General Services Administration has undertaken two new initiatives to facilitate the purchase of microcomputers by Government Agencies: Schedule C and the Federal Information Product Center. Federal Supply Code 70 (automated data processing equipment) Schedule C is a specially negotiated pricing schedule between the GSA and large volume vendors of microcomputers which contains the lowest prices available to the Government under most circumstances (exceptions are very large lot purchases by individual agencies). Agencies place their orders with GSA which in turn combines the orders, places them with the appropriate vendors, and then distributes the microcomputers to the ordering organizations. The Federal Information Product Center is a retail-store like setting operated by a contractor in Government supplied space. The contractor acts much as any retail computer store, i.e. supplying microcomputers, general training classes, specialized training and consulting (on a fee basis), and repair services. As a result of this arrangement, it is expected that the Government will get better prices than generally available in retail establishments while providing users with the convenience and level of service that such stores can provide (see section 5.5.3).

5.5.2. Internal Sources

An alternative to GSA schedules is the centralizing of microcomputer purchases at the agency (or even regional) level. Internal organizational entities can supply microcomputers in a number of ways including the following:

<u>Internally Developed Microcomputer</u>

If a large number (on the order of thousands) of microcomputers are to be installed, economies of scale may favor the internal development and support of a microcomputer. The use of a standard bus can reduce costs and enables users to install specialized component boards in areas such as laboratory automation and data collection. Common components can be locally stocked for readily available spares with a consequent reduction of repair times and cost. If common microprocessors and operating systems are used, a large base of software is available.

<u>Centralized Purchases of Microcomputers from a Single Vendor</u>

This is the most easily implemented, justified, and certain approach from the procurement and implementation point of view. Even if an external supplier is used, agencies may consider the use of Government employees for all support activities to increase system availability and performance and to reduce the risk of being left without support should the vendor abandon the product line.

<u>Centralized Purchases of Several Computer Product Lines</u>

The purchase and support of several microcomputer lines reduces the risk of obsolescence and dependence on a single supplier while sacrificing some of the standardization advantages noted previously. This approach is also functional in situations where microcomputers are being used in settings with widely varying user requirements (e.g. document preparation and laboratory automation).

5.5.3. External Sources

The use of external sources provides the widest choice at some penalty in time and paperwork. It is therefore justified when making large procurements or pilot purchases. Federal acquisition regulations provide three purchasing alternatives: GSA Federal Supply Code 70 Schedule A, competitive procurement, and noncompetitive procurement with sole source justifications. GSA Schedule A is a list of prices that have been offered to the Government by vendors of microcomputers. Generally, these prices are discounted from list, but further discounts are sometimes possible by means of direct negotations. Competitive procurement is a more complicated process which involves announcing the procurement in the <u>Commerce Business Daily</u>, allowing vendors an adequate time to respond, and then evaluating the bids of all respondents. The process may take several months, and is best used for larger procurements. Noncompetitive procurement is possible if one source is clearly more qualified. Justification for sole source procurements must be provided and approved, a process which may also cause a delay of several months. An

example of a case where such a procurement is justified is the enhancement of an installed microcomputer-based local area network.

Microcomputers, software, peripherals, and other accessories can be obtained from a variety of sources including manufacturer's sales representatives system integrators, retail computer stores, consultants, direct mail, user's groups, and related sources.

Manufacturer's sales representatives have been the primary source of larger computer systems, and continue to be a source for large volume purchasers of microcomputers (such as Federal agencies). The primary advantage of buying through these representatives is the ability to maximize agency influence resulting from large orders. Interaction with these representatives can facilitate the obtaining of proper support, favorable resolution of hardware and software problems which are (or possibly are) the fault of the manufacturer, early knowledge of new or planned product announcements, and ability to obtain very specialized and expert advice in new or demanding applications development. However, because of the costs involved in maintaining a direct sales force and providing the additional user support, manufacturer's representatives may not provide the lowest price for systems and software. Moreover, the fact that sales representatives are largely on commission may result in overly optimistic claims of equipment capabilities and the overlooking of more cost-effective alternatives.

System integrators, also known as OEMs (Original Equipment Manufacturers), provide complete systems based on components from a number of manufacturers. OEM organizations have been a prominent distribution channel for minicomputers, systems which both required a significant amount of technical support and provided relatively high unit profits. In microcomputers their major role seems to be evolving into serving as marketing and distribution entities for smaller manufacturers which produce high-end systems and can not afford their own sales organizations. Thus, the hardware offered by these sources may provide some unique capabilities such as multiuser capabilities, more advanced microprocessors, and more sophisticated operating systems. However, these systems are generally not the popularly recognized (and highly marketed) brand names, and their greater complexity and smaller production runs will probably result in more operating problems and the consequent need for greater support. Unfortunately, continued support of such products depends solely on the viability of both the system integrator and manufacturer and their commitment to a product line which may no longer be sold. In the rapidly changing and highly competitive world of microcomputers, this commitment is far from assured.

Retail Computer stores are the most prominent distribution channel for microcomputers; estimates of their portion of sales range as high as 70% [FINK83]. Three major types of computer stores can be defined: manufacturer owned retail outlets, franchises, and independents. Manufacturer owned retail outlets carry only a single product line and will not provide discounts for small quantity purchases (unless the particular product is being discontinued). However, because of the organizational ties, these outlets provide the highest levels of product availability and support -- in some cases, they are the only sources for certain products. Franchise stores deal with several lines of products, and are generally required to conform to

minimum standards of service and support. Because of these standards and their policies of selling the most popular systems, they provide a relatively low risk means of purchasing systems. However, prices are generally dictated by franchise-wide policies, their product offerings are limited to a few best sellers in both hardware and software, and these dealers may have limited abilities in the areas of technical support and service. Independent computer stores comprise the largest and most heterogeneous portion of the retail distribution channel. Some independent retailers are quite similar to OEMs in their high level of support — the only difference may be the existence of a store front. Others provide discount prices as a means of competing against the better funded franchises and manufacturer-owned outlets. Most also rely on personalized service, support, and technical capabilities to attract follow-on business and referrals.

The effectiveness of all types of computer stores for the sales and support of microcomputers can be seen in the fact that many large organizations procure their systems through these outlets [BUSW82, FINK83]. Motivations for Federal agencies to use these sources include policies encouraging the use of small local businesses, the ease of procuring systems, and the level of support provided to major clients. However, there are some drawbacks to the use of computer stores as the primary microcomputer procurement and support source. The unstable, capital intensive, and highly competitive environment in which microcomputers are manufactured and sold is not particularly conducive to small businesses, and their long term survival is by no means assured.

Some microcomputer consultants have become sources of microcomputers through their activities on implementing systems in small and some medium sized organizations. Their operations are quite similar to those of OEMs and value added dealers, but their commitments to a particular manufacturer may be less formal, and therefore more subject to change. Under the best circumstances, consultants with expertise in the application area and good relations with various manufacturers and distributors can provide the most cost-effective means of implementing systems. Under other conditions, customers have to pay for the time to learn the particular application, and the consultant may not be sufficiently knowledgeable to make the correct decisions. Because of the relatively small number of independent microcomputer consultants, this channel is relatively unimportant for most purchases. However, if many systems in a specialized application are being procured, a consultant with a good reputation and relevant expertise may be the most appropriate source.

Mail order is generally the means of obtaining the lowest purchase price for microcomputer systems, peripherals, and software. It is also the one with the highest risk and lowest level of support. The optimal use of mail order sources is the purchase of products already in use within the organization. In these cases, the compatibility and performance of the products are known, and testing of ordered products can be easily performed by comparing with units currently in use (it is not uncommon for both hardware and software shipped through normal mail or package handling companies to be defective when it arrives). Knowledge of mail order prices is also important in conducting negotiations with other sources of microcomputers. The ability to quote a lower price from a mail order source is often the most effective means of getting a lower price from a more direct source.

User groups and "communities" which have congregated on various private and government networks are a source for a variety of public domain software, some of which is quite powerful. For example, one of the most sophisticated RS-232/modem microcomputer communication packages is readily available from the ARPANET, and the New York CP/M User's Group has some 20 disks of software available for the cost of the duplication, shipping, and handling. Unfortunately, the quality of such software is not uniform, and direct contact with the author (if known) is the only source of support. Thus, use of such software requires a significant investment of time and expertise, and is not recommended for non-technical users. On the other hand, if a public domain software package can be adapted for use on a large number of Federal systems, it may be preferable to the purchase of proprietary packages.

CHAPTER 6 - CONCLUSIONS

Section 6.1 discusses recommendations to end users and section 6.2 lists areas where further guidance and standardization activities are desirable.

6.1. SUMMARY OF KEY POINTS

All readers considering the implementation of microcomputers in their agencies should be aware of the following:

Microcomputer Technology is Advancing at a Rapid Rate

The performance advances made by mainframe manufacturers in two decades have been made by microcomputer manufacturers in five years. The unprecedented rate of new product offerings and a changing market require full-time personnel for effective monitoring. Users attempting to select microcomputers should either be cognizant in the current state of the technology themselves or use the services of those who are — especially for large procurements. The cost of such expertise is justified by the value to the organization in avoiding the risk of inadequate systems rather than the price of the equipment and software being procured.

Microcomputers Require Constant Support

Unlike typewriters, copiers, or some other office equipment, microcomputers require continuous support in the form of training, maintenance, and new applications. The major objective of organizational microcomputer policies is to ensure that users have such support. Unsupported systems soon become a liability to the organization.

Application Software Should Be the Basis for Microcomputer System Selection

Although intuition suggests that the computer hardware is the driving force behind computer acquisition, it is actually a secondary consideration. Nearly all 'business' (as opposed to home oriented) microcomputers have adequate computation capacity for most Government applications, but not all are compatible with the applications software which are required by users. Because the software defines the functionality of the computer, it drives the procurement decision.

Successful Implementation of Microcomputers Requires a Broad Perspective

A broad range of organizational, psychological, ergonomic, hardware, and other issues must be considered. This large number of factors may result in conflicts or incompatibilities which must be resolved by re-iteration of some of the steps in the selection process. The investment of time in the system procurement phase will result in substantial benefits over the system life.

User Responsibility and Control

A significant difference between microcomputers and mainframes is the primary focus of responsibility: for mainframe computers, primary responsibility and control is placed within a dedicated department; in microcomputers, the end user has primary responsibility.

This change in the focus of responsibility poses a challenge to traditional ideas on the management and control of computing resources in large organizations. Personal computers are controlled by individuals, not data processing departments. Although this control has resulted in greater responsiveness to individual interests, it has caused significant problems for managers of information resources in Federal agencies. As noted in Chapter 5, this problem is not simply a matter of jurisdictional disputes; Federal statutes require the oversight of Government data processing equipment (including personal computers) to prevent fraud, waste, and abuse. Thus, although end users now have unprecedented access to computers, they are subject to controls and must be aware of the larger context in which they are working. This context consists of both technical aspects -- i.e. compatibility with existing communication systems, mainframe computers, or local area networks -- as well as organizational aspects -- i.e. management of data security, data integrity, and other issues.

User Interaction

Users can control all aspects of the computer operation and can therefore tailor computer operations to suit their own needs, eliminate delays, and reduce costs. However, inexperienced users also have an unprecedented degree of interaction with a very complex system. Because of the limited expertise of most users, the system must provide a "friendlier face" to users (i.e. operators) than in larger systems.

This interaction causes a number of differences in the way data processing occurs on microcomputers. In larger systems, a number of individuals with specialized knowledge of system operation, system programming, application programming and data entry are involved. On a microcomputer these tasks are performed by a single individual. Although the tasks are significantly simpler than the corresponding ones on larger systems, end users must acquire a significant body of knowledge in order to use these systems effectively. It is ironic that the breadth of knowledge required of millions of unsophisticated end users is not required of experts on the larger systems.

Performance

Microcomputers typically have smaller memories and slower central processing units than their larger counterparts. Thus, some

applications which run on larger computers (e.g. large scientific or accounting programs) cannot be easily converted to microcomputers.

Security

Because a single user can have exclusive control of the entire microcomputer system, microcomputer security is often less of a problem than security on mainframes. Users can physically remove and restore all critical data during the course their sessions, and can store removable mass storage devices such as disks or tape in the same manner as confidential documents and film. However, the ability to easily transport machine readable data makes organizations more vulnerable to the misuse of data by employees with access authorization. Covert movement of a single disk or tape across a security boundary to a compatible unauthorized system is much easier than the movement of documents or the larger disks found on minicomputers and mainframes.

Common Data

Data sharing is useful in administrative, legal, technical, and other settings. Unfortunately, single-user microcomputer systems are not amenable for communal access to a single data file. Although multiuser systems allow common access to a single data storage device (e.g. a hard disk), most do not have software which allow common simultaneous access to a single file.

6.2. USEFUL AREAS FOR GUIDELINES AND STANDARDIZATION ACTIVITIES

Desirable guidance and standardization activities are discussed according to the user classification of Chapter 3.

6.2.1. Clerical Users

Useful guidance pertaining to clerical users can be provided in the following areas:

Ergonomic Design of CRTs and Keyboards

As has been noted previously, attention has been focused on the ergonomic aspects of CRTs and keyboards and their psychological and physiological impact on operators. Ketch [KETCH83], Bond [BOND82], and other authors have suggested a number of useful criteria, although all point out that they are based more on intuition than on definitive research results. Continued investigations in this area are in progress.

Integration of Microcomputers in Larger Systems

Standardization activities in the area of office automation will aid in the integration of microcomputers into larger systems including the ability to communicate with other computers and to process data files produced by other software. Recent efforts from NBS include guidance in

the setting of requirements [NBS80], coded character sets for text processing [NBS81], and message interchange format standards [WATK82].

Application Software for Clerical Users

Clerical users can benefit from microcomputer software in the areas of word processing, data entry, and communication. Guidance in the setting of requirements and evaluation of existing systems is beneficial to these personnel.

6.2.2. Managerial and Administrative Users

Useful guidance to managerial and administrative users can be provided in the following areas:

Appropriate Usage of Microcomputers

Guidance on the appropriate use of microcomputers will maximize benefits and reduce organizational risks associated with their introduction. As experience with managerial and administrative usage of microcomputers increases, knowledge of the important organizational variables which determine appropriate and inappropriate microcomputer uses will become available. Until that time, it should be recognized that extensive commitments to microcomputer use in applications where there is no past experience (in either the public or private sector) carries some risk. Guidelines based on past successes and failures are frequently published in trade journals [BLAN83, GULD82, MCCU82, OHAR82, ROMA83, STJO82, SMEJ83, WOHL82, and others].

Office Automation

Administrative users will benefit from guidelines in office automation and in integrating microcomputers into such systems in a manner similar to clerical users [GAO82, BECK82, MEYE82].

Communication with Larger Systems

Administrative users can benefit from the ability to retrieve information from a centralized computing resource for local manipulation and display. This capability involves communication standards on a technical level as well as guidelines in the appropriate use of this information on the organizational level.

Application Software for Administrative and Managerial Usage

At least five key microcomputer application software areas are useful to administrative and managerial users: word processing, data management, spread sheet analysis, graphics, and communication. The greatest benefit of such software can be obtained if new products are tested and evaluated in a centralized Government agency. In addition, guidance on the setting of requirements in new application areas is also useful.

Additional software related to specific functions (e.g. project management or accounting) can be useful if it conforms to current policies and guidelines. Standards for accounting software have been stated by the General Accounting Office [GAO78], and numerous reporting formats for project management have been defined by a variety of Government agencies. Activities in the areas of certification of software to fulfill these requirements on the parts of individual agencies or centralized functions would be particularly beneficial to managerial users.

6.2.3. Professional Users

Professional users can benefit from guidelines and standards in the following areas:

<u>Communication with Larger Systems</u>

The ability to use software and data residing on mainframes (e.g. statistical analysis packages or economic data) in conjunction with software on microcomputers (e.g. spread sheet packages, graphics, or data management systems) can result in large productivity increases for these workers. Thus, these users will benefit from standards in computer communication including both low levels (i.e. those related to the control of the data flow and the actual physical interconnection) as well as on the application level (e.g. converting data from a mainframe into a format usable by microcomputer applications).

<u>Microcomputer Application Software</u>

Professional users will benefit from standards in the five general application areas given for administrative users. In addition, these users will benefit from a central source of information and guidance on specific packages in medicine, agriculture, earth science, social science, and other areas.

6.2.4. Technical Users

Technical users will benefit from guidance and standardization activities in the following areas:

<u>Software Development Practices</u>

Disciplined software development practices may still be a novel subject to many microcomputer programmers. Recently announced microcomputer software development systems which are based on either specialized microcomputer hardware or minicomputers may aid in this process. However, the field is still relatively new, and additional conceptual work is necessary. A companion report [NBS83a] discusses this area.

Language Processors

Standards for microcomputer language processors (i.e. compilers and interpreters) currently lag behind the state of the industry, and, as a result, the dominant products often become the de facto standards. In some cases, standards for compilers used on larger systems can serve as a useful basis for certification. Thus, the General Services Administration has recently certified several FORTRAN, COBOL, and BASIC implementations for microcomputers based on their standards for mainframe compilers.

Communications

The importance of communications for all user groups has previously been stressed. However, the existence of standards in this area is particularly beneficial to technical users who, in many cases, are responsible for building computer networks and writing the communication software. Current work by the IEEE, the ISO, and hardware vendors may have a large impact on this area in the near future.

Data Formats

The ability to exchange data between two processes (on either a single computer or two separate systems) depends on a uniform file structure and data format. Work in this area is currently underway at NBS [WATK82], and several microcomputer software vendors have published their own standards for the transmission of spread sheet and graphics data. However, with the exception of the ASCII character set, this area remains largely unresolved, and additional work is necessary.

Operating Systems

One of the main reasons for the success of microcomputers has been the dominance of a single operating system for the most common 8 and 16-bit microprocessors. However, the advent of more powerful systems and the introduction of numerous equivalent (but not compatible) products aimed at both software developers and end users may change this situation for the worse. Examples include the large number of UNIX variants and the recent introduction of mouse-based operating systems or application environments. Some standardization efforts are under way (e.g. the UNIX standards committee of /user/group), but additional work in this area is necessary to prevent the proliferation of different systems.

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APPENDIX A - GLOSSARY

The major objectives in formulating the definitions in this glossary were conciseness and simplicity. Thus, less common uses of some terms are not presented. More formal and authoritative definitions are available in the following sources:

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abort - the termination of computer program execution prior to its completion.

absolute machine code - a type of machine language which must be placed in a given part of memory in order to be executed.

acceptance testing - testing conducted to determine whether a system satisfies specific criteria and to enable the customer to determine whether to accept the system.

acoustic coupler - a device to connect a computer or terminal to the handset of a telephone for data transmission (see also modem)

address - the designation of a particular memory location where data are stored or a port location where a device may be accessed

algorithm - a finite set of well-defined rules that gives a sequence of operations for performing a given task.

alphanumeric character - a letter or number

applications software - software which performs a specific task such as word processing, spread sheet analysis, etc. (compare with system software)

ASCII - American Standard Code for Information Interchange. A standard for the representation of 96 characters, digits, and printer control commands as a series of 7 bits. The ASCII code is the most commonly used standard for the representation of characters in memory and for data communication.

assembler - a computer program used to translate a program expressed in an assembly language (see below) into a machine language. This process is usually accomplished by substituting machine codes for assembly language mnemonics (see assembly language, below) and by replacing various forms of symbolic addresses with specific memory addresses.

assembly language - a machine-specific language whose instructions are usually in one-to-one correspondence with computer instructions.

asynchronous serial communication - the communication of individual characters over a communication channel as a series of bits. At the beginning of each character, a "start" bit is sent to indicate a new character.

background processing - the execution of lower priority computer programs when higher priority programs are not using system resources such as the CPU. Example: a user is editing a document while printing another in background.

back up - a duplicate of a hardware system, of software, or of data intended as a replacement in the event of a malfunction.

batch processing or batch mode - the execution of a program or set of programs on the basis of a single initiating action (compare with interactive processing)

baud - A measure of transmission speed originally applied to teletype terminals using the baudot code. Although not strictly the same, baud and and bits per second are equivalent when used for digital communication with the ASCII code (see ASCII, bits per second).

benchmark - the measurement of performance against a uniform set of standards.

bit - contraction of "Binary digit". The smallest unit of information. A bit can represent two values such as off/on, yes/no, true/false, or 0/1 (see also byte).

bits per second - a measure of data transmission speed: number of bits transmitted through a data channel in one second.

bootstrap - a short computer program that is placed in ROM and whose execution brings an operating system (or other large program) into computer memory.

BPS - see bits per second.

buffer - an area of RAM that is used to temporarily store data from a disk, communication port, program, peripheral device.

bug - an error, mistake, or malfunction in a computer program (see debugging)

byte - usually a group of eight bits. Bytes are the most convenient units for storing letters or characters (because of the ASCII code), computer instructions, and system status indications.

cathode ray tube display - A television-like display that is commonly used with a keyboard for displaying user input and computer responses. Also referred to as "video display tube" or VDT.

cell - a location on a spreadsheet where either data or a formula is stored.

central processing unit - The "heart" of the computer which executes instructions and computer programs.

code - (1) the representation of data or a computer program in memory such that it can be executed by the central processing unit; (2) the process of writing software; (3) one or more computer programs or part of a computer program; (4) encryption of data for security purposes.

command oriented software - software which responds to a command string entered by the user (generally through a keyboard). Compare with menu oriented software.

compiler - A computer program which translates a high order language program into machine language which can be executed by the central processing unit.

component - a basic part of a system or computer program.

computer program - a sequence of instructions executed by the central processing unit.

concurrent processes - processes (i.e. computer programs) that are executed simultaneously.

conversion - modification of existing software to enable it to operate in a different language, on a different system, or both

CPU - see central processing unit

CRT - see cathode ray tube display

cursor-location marker on a computer display screen, usually an underline or rectangle.

custom software - software specially developed for an individual application.

data base - Informal: information stored in a computer. More formal: a (1) a set of data, part or the whole of another set of data, and consisting of at least one file that is sufficient for a given data processing system; (2) a collection of data fundamental to a system; (3) a collection of data fundamental to an enterprise.

debugging - correcting mistakes in a computer program (see bug)

default condition or setting - a condition or setting that exists until changed by the operator. An example of a default condition is a standard 66-line page.

digitizing tablet - a device which indicates the relative position of a stylus (or similar device) on a surface to the CPU.

disk - a circular, flat object made of plastic or aluminum and coated with magnetic material used for storing information.

disk cartridge - a disk and the surrounding packaging material also referred to as a disk pack. Generally used in relation to removable hard disks.

disk drive - the mechanical device and electronics which read and write data from the disk into the CPU and memory.

diskette - a small disk. Generally used when referring to floppy disks of 8 inch size or smaller.

documentation - Technical data, including computer listings and printouts in human-readable form which (1) document the design or details of the software, (2) explain the capabilities of the software, or (3) provide operating instructions for using the software to obtain the desired results from computer equipment. It also includes program listings or technical manuals describing the operation and use of programs.

editor - a computer program that permits selective revision of computer stored data.

efficiency - the extent to which software performs its intended functions with a minimum consumption of resources.

execution - the process of carrying out an instruction or the instructions of a computer program by a computer.

field - a place in a record or file for storing an individual item of data such as a name, account number, etc.

file - a collection of records or data which is stored, used, or generated by a computer program.

filter - a program which takes the output from one program, performs an operation on it, and passes it along to a second program. The term originated in the UNIX operating system (see also pipe).

firmware - computer programs and data loaded in a class of memory that cannot be easily modified by the user during processing.

floppy disk - a disk made of mylar or a similar flexible plastic material and coated with magnetic particles and packaged in a paper jacket. Common diameters are 5.25 and 8 inches. Also referred to as flexible disks.

font - typeface style (e.g. Italic, Courier, Letter Gothic, etc.)

footprint - the area of a desk, table, or other flat surface taken up by the microcomputer and associated equipment.

foreground - the primary task being executed in a computer where several tasks are being run simultaneously. Example: a user performing a text editing task in foreground while another document is being printed in background.

hard copy - computer output printed on paper (as opposed to a disk or a CRT).

hard disk - a disk of aluminum or other rigid material which generally has greater storage capacity and allows for higher access speed than a floppy disk. Also referred to as a rigid disk.

hardware - the electronic and mechanical devices that comprise a computer system.

help facility - software which controls the display of instructions on the CRT screen when the user requests information while running a program.

high level language - see high order language

high order language - A computer programming language that does not reflect the structure of any one given computer and that can be used to write machine independent programs. A single high order language statement may represent many machine operations.

implementation - (1) a realization of an abstraction (e.g. a system design) in more concrete terms (e.g. the actual system); (2) the process of translating a design into a working computer program.

information utility - see value added network

instruction set - the set of instructions which a central processing unit performs.

input - data entered into a system program by an operator, from a file, or from another device (e.g. a piece of laboratory equipment).

install - (1) the act of bringing a computer to the location where it is to be used and performing tests to ensure that it is operational; (2) the act of adjusting parameters on a purchased computer program so that it is compatible with the particular hardware and peripherals on an individual system.

installation - a way of referring to the computer system (e.g. "...this microcomputer installation performs the following functions:..."); also can be used as noun form of definitions (1) and (2) of install (above).

integration - ensuring that all components (both hardware and software) of a particular system work together and making the appropriate changes when they do not.

interactive processing - a type of program execution in which the user is involved in the data input and control. Its purposes include the provision of immediate feedback to the user, the exchange of information between the computer and the user, and the correction of data input errors.

interface - (1) a shared boundary; (2) a hardware component which links two or more devices; (3) that function of a computer program which presents information to an operator and accepts user responses.

interpreter - a computer program which translates and executes each statement of a computer language written in a high order language (e.g. BASIC or Pascal) before proceeding to the next.

joystick - a stick-like pointing device (typically 1" to 3") which can be used to indicate the speed and direction of cursor movement to the CPU.

justification - the alignment of letters on a margin (e.g. this glossary is right-justified).

light pen - a pointing device which uses light from the CRT to indicate position to the CPU.

maintenance - see software maintenance

machine language - a representation of instructions and data that is directly executable by the central processing unit.

macroassembler - an advanced type of assembler that allows the user to define a sequence of instructions that are inserted into a program during assembly.

menu - a screen display which lists tasks the computer can perform so that the user can select the desired operation.

menu-oriented software - software which responds to the designation of a choice from a menu (see above) rather than an explicitly typed in command.

merge - the combining of information from two sources (generally two data files) into a third.

microcomputer - a computer system consisting of a central processing unit, random access memory, and interfaces to pass data to and from peripherals (such as disk drives) which is based on a microprocessor.

microprocessor - a central processing unit in a single integrated circuit.

modem - acronym for modulator/demodulator. During data transmission, the modem converts the computer representation of data (generally a voltage level) into an audio signal for transmission of telephone, teletype, or intercom lines. When receiving data, the modem converts the audio signal to the computer data representation.

module - a well defined section of a computer program with a specific function such as accounts receivable.

mouse - a small handheld pointing device which, when moved on a flat surface, causes a corresponding movement of a cursor on a CRT

multiprogramming - see multitasking

multiprocessor - a computer which consists of several processors which may execute programs simultaneously.

multitasking - the concurrent execution of several programs.

object program or module - a fully compiled or assembled program that can be loaded into a computer memory and executed.

off line storage - storage of data on media which are physically removed from the system (e.g. a magnetic tape or a floppy disk) and stored elsewhere.

operating system - a computer program that controls the operation of the computer including the execution of other computer programs, the routing of data, and the control of peripherals.

output - information that comes from the computer as a result of its processing.

overlay - the technique of running a program which is too large for the computer memory by keeping inactive parts on disk.

parity bit - a bit indicating whether the sum of a previous series of bits (generally a single character in asynchronous serial communication) is even or odd.

parity checking - the comparison of the sum of a previous set of bits with the parity bit to determine if an error in the transmission or receiving of the message has occurred.

password - a code word required to use a computer system or gain access to program or data files.

patch - a modification of a program written in machine language that may be used to replace another part of a program (which is generally an error) without going through reassembly or recompilation.

peripheral - a device such as a CRT, printer, or disk drive which is not an integral part of the CPU and memory or devices which provides the CPU with outside communication.

pipe - the means by which data are passed through a succession of tasks (some of which may be filters). The term originated in the UNIX operating system (see also filter).

pointing device - a device which is used to communicate cursor position information to the CPU.

portability - a quality which describes the ease with which software can be transferred from one computer system to another.

print spooling - the ability to print the contents of a file in background while another task is being executed in foreground.

prompt - a message informing a user that a system is ready for the next command, message, or other user action.

protocol - a set of rules that govern the way in which computers or other functional units transfer data.

RAM - acronym for random access memory (see below)

random access - the ability to access a particular data item without having to read through all previous items.

random access files - files which are structured to allow access to any particular record without having to search through all previous records in a file.

random access memory - a memory that can be read or altered directly by the CPU. The most common types of random access memory retain their contents as long as the system has power, but lose them whenever the power is turned off.

read-only memory - a memory that can be read by the CPU but can not be altered. Generally this memory retains its contents in the absence of electrical power.

read-write memory - see random access memory

real time computing - the performance of a computation during the time that a related physical process happens so that results of the computation can be used to guide the physical process.

record - a collection of related data treated as a unit.

requirement - (1) a condition or capability needed by a user to solve a problem or achieve an objective, (2) a condition or capability that must be met or possessed by a system in order to satisfy a contract, standard, specification, or other formally imposed document. The set of all requirements forms the basis for subsequent development of the system (see also specification).

sequential access - the ability to access data in a sequential manner, i.e. the order in which it is stored. The best example of sequential access is a file stored on magnetic tape. However, files stored on disks may also be sequential.

software - computer programs, procedures, rules, and possibly associated documentation and data pertaining to the operation of a computer system.

software maintenance - modification of a software product after delivery to correct faults, improve performance or other attributes, or to adapt the product to a different system.

sort - the ordering of data (most commonly records) in a specific order, e.g. alphabetically, in ascending numerical order, etc.

source code - the form of software used by programmers to create and modify software.

specification - (1) a document that prescribes in a complete, precise, verifiable manner, the requirements, design, behavior or other characteristics of a system or component, (2) the process of developing a specification, (3) a concise statement of system requirements to be satisfied by a product or system indicating, whenever appropriate, the procedure by means of which it may be determined whether the requirements given are satisfied.

support - the provision of advice and expert assistance in the operation of the computer system and application software.

system - a collection of people, machines, and methods organized to accomplish a specific set of functions.

system software - the operating system and accompanying utility programs that enable a user to control, configure, and maintain the computer system, software, and data.

utilities - computer programs or routines which perform general data and system related functions required by other application software, the operating system, or users.

validation - the process of evaluating software to ensure compliance with software requirements and correctness.

value added network - a network of computers owned or controlled by a single entity which can be used for data transmission, electronic mail, information retrieval, and other functions by subscribers.

virtual memory - a technique by which the central processing unit can use more memory than is available in RAM. The operating system writes the contents of inactive memory to a disk drive when that portion of memory is needed for another purpose and retrieves the contents from the disk as appropriate.

Winchester disk - a type of rigid disk in a sealed unit.

APPENDIX B - ANNOTATED BIBLIOGRAPHY

This appendix lists some of the useful books and articles which were encountered in the course of preparing this report. This list emphasizes works which can be read with little or no previous computing background, and are organized according to the following topics:

General Overviews
Microcomputer Market
Word Processing and Auxiliary Programs
Administrative Applications
Communications
Organizational Issues

GENERAL OVERVIEWS

Laurence Press, "Getting Started in Personal Computing", onComputing, Spring, 1981, p. 8

Describes microcomputers with an emphasis on the basic hardware components. The article can be easily read by those without prior knowledge of computing.

Carol Brown, The Minicomputer Simplified, The Free Press, New York, 1980

A book oriented to non-technical managers in organizations considering the introduction of minicomputers. The volume is well written, and most of the material on computer hardware and software development is relevant to microcomputers as well.

D. Whieldon, "Make Way for Microcomputers", Computer Decisions, June, 1982, p. 158

Describes microcomputers from managerial point of view and does not require any computing background for understanding. Gives examples of applications and describes motivations for use. The article also includes a discussion of organizational issues including management, configuration control, and relations with the data processing department.

H.D. Toong and Amar Gupta, "Personal Computers", Scientific American, December, 1982, p. 86

A more serious and thorough overview intended for a scientifically sophisticated audience but not one which is expert in computing. Describes hardware, the functional organization of microcomputers, some of their history, market trends, and applications.

Appendix B - Annotated Bibliography

Otto Friedrich, et al., "The Computer Moves In", Time Magazine, January 3, 1983, p. 14

An easily read series of articles which describe the Time Magazine "Man (Machine) of the Year". Although not technically informative and overly sensational in some areas, the articles can provide readers with a feeling of the microcomputer industry personalities, major companies, and some future market trends.

MICROCOMPUTER MARKET

International Data Corp., "Computer Systems and Services", Fortune, May 16, 1983, p. 24

A marketing oriented overview of the microcomputer industry which is a digest of the results of past IDC studies. Although covering all aspects of the computer industry, the bulk of the report covers microcomputing and related topics.

Staff, "Special Report: Look Ahead 1983", Business Computer Systems, January, 1983

A digest of projections and expert opinions and projections on the microcomputer industry. Somewhat sensationalized, but some interesting ideas, e.g. "the office of the future is as far off as it was five years ago"; "by 1990, every manager will have computing power through desk top systems"; and "computing power is a commodity..like electricity"

WORD PROCESSING AND AUXILIARY PROGRAMS

Laurence Press, Low Cost Word Processing, Addison Wesley, 1983

This book describes word processing on microcomputers and is oriented to readers with no prior experience. As part of the discussion, the book also describes microcomputer hardware, software, and integration of word processing with other applications. A list of selection criteria, sample hardware configurations, and vendors is also included.

Terry Kepner, "Spelling Checkers for the TRS-80", Popular Computing January, 1983.

This article compares four spelling checkers for the TRS-80 and in doing so presents a checklist of 20 program attributes. A discussion of the pros and cons of each program is also provided.

Robert Perry, "Mailing List Packages -- a Mainstay for Business", Personal Computing, January, 1982.

This is a comprehensive article covering mailing list packages. Several sample applications are outlined and package features are discussed.

Record definition, sorting, file size, retrieval, report generation, and mailmerge are covered. Eighteen packages are reviewed briefly, each has a one-paragraph description and a checklist of features and capacities is presented.

Karen Shelby, "Information Processing in a Legal Environment", Proc. Synoptican X, Kansas City, MO, June 24, 1982

Defines the functional requirements of computing in a private legal firm.The most important need is multiuser word processing (i.e. the ability of several typists to work on the same document). Other needs include timekeeping, schedules, and docket control.

ADMINISTRATIVE APPLICATIONS

Andrew Fluegelman, "Visi-Calc versus SuperCalc, a Head to Head Comparison", PC Magazine, August, 1982.

This article compares the two programs and in doing so establishes a framework for comparison with other interactive spreadsheet processors. Some basic terms are defined and several general areas are covered, including, interaction and data entry style, arithmetic precision, formatting options and flexibility, display data types, replication, cursor movement, block operations, windowing and protection, functions and operators, speed of calculation and file transfer, output options and documentation. An informal description of a pre-release version of Multi-Plan appears in the same issue of the magazine.

Myron Berger, "Scenarios for Success: The Vision of Spreadsheeting", Personal Computing, April, 1982.

This is a short article written for the beginner. It briefly describes what a spreadsheet program is and then gives a number of examples, based on mini-interviews with users. The applications stress the ease of "what if" analysis and cover areas such as proposal and bid preparation, business plans, alternate budget scenarios, and aggregation of departmental budget reports. Resources such as newsletters, users groups, prewritten applications and books are also mentioned briefly.

Robert R. Mueller, "Business Planning Software", Personal Computing, November, 1982.

This article discusses non-planning applications of planning software, makes the distinction between screen-oriented and program-oriented programs, and covers the use of models. The author feels that the program-oriented languages are easier for clerical people to run once the model has been constructed by a professional. The necessity of understanding the assumptions programmed into any model you use and the risk of not doing so when using commercially available templates (pre-programmed models) is emphasized. A list of several software suppliers is included.

Appendix B - Annotated Bibliography

Carl Heintz, "Evaluation of Financial Planning Packages", Interface Age, July, 1982.

This article sets out a framework for the comparison of financial planning packages. Some earlier timeshared packages are mentioned for historical perspective and the distinction between screen- and program-oriented languages is drawn. The author feels that in general, screen-oriented languages are less powerful, but simpler for non-programmers to learn to use, since they are less abstract. The bulk of the article is taken up with brief comments on each of 28 attributes which may be used in comparing programs. A checklist accompanies the article, scoring 32 programs on the 28 attributes.

Jack Bishop, "Beyond the Peaks of Visicalc", Byte, October, 1982, p. 29

This article compares three spread sheet processors with VISICALC and includes some insights on spread sheet operation and user criteria in addition to a discussion of the merits of the three packages.

M. Lasden, "Computer Aided Decision Making", Computer Decisions, November, 1982, p. 158

Defines the requirements for a computer-based "decision support system" which includes data query and retrieval, spread sheet analysis, and graphics. Points to need for mainframe based decision support systems on the basis that some applications are too big for a microcomputer in large organizations.

COMMUNICATIONS

Michael Killen, "The Microcomputer Connection to Local Networks", Data Communications, December, 1982.

This article summarizes an extensive report prepared by Strategic Inc. It surveys the low-speed local network market, as opposed to Ethernet or broadband networks. There are about 12,000 low speed networks installed as compared to 800 high speed networks. A typical configuration is four personal computers with floppy disk, and a shared hard disk and printer. Typical data rate is 3 million bps. The cost of a typical network interface is $500 today and is expected to drop to about $50 by 1987 (compared to $2,000 and $500 for Ethernet). The author states several advantages of LANs over timesharing and gives brief descriptions of 16 products. Four installation case studies are also summarized briefly. The lack of standards is noted; however, Corvus and Datapoint are encouraging other vendors to use their networks.

Wallace B. Riley, "Local Area Networks Move Beyond the Planning Stage", Systems and Software, November, 1982.

This article surveys LAN technology choices. Baseband and broadband are both covered in roughly the same depth. Pros and cons of the two approaches are mentioned. Issues and terms encountered in PC networks

(virtually all baseband today) such as random versus controlled access, collision detection and token passing strategies are summarized.

G. FitzGerald and T.S. Eason, Fundamentals of Data Communication, Wiley, 1978

This book provides a fundamental description of data communication. Because it is intended as a textbook in management schools, the book is rigorous but does not require a technical background. However, some background knowledge of computing is necessary. Although not aimed at microcomputers, the technical concepts it discusses in the areas of both synchronous and asynchronous communication are relevant.

Tony Bove, "What is Teledon, and Why is AT&T Adopting It?", Datacast, No. 1.

Teledon is a presentation level protocol for the communication of text and simple pictures between computers. The notation for describing pictures consists of a "command" specifying text, point, line, arc, rectangle, polygon, bit-mode or control-message, followed by coordinates (9-bit accuracy) and operands. The notation is not fully specified in this article, but a discussion of standardization in the general "videotext" area is presented as are descriptions of 12 Teledon-based projects in the US and Canada. Teledon interpreters have been implemented on several personal computers.

Errol Smith, "Videotex", CP/M Review, January/February, 1983.

AT&T has proposed a new standard for picture and data transmission. It is now being studied by ANSI. The protocol includes provision for text, mosaic graphics, lines and shapes, a redefinable character set, and some control operations. This article summarizes the protocol.

GRAPHICS

Elisabeth Bayle, "Picture This and Do it Yourself", Personal Computing, August, 1982.

An introductory overview of business graphics applications and software. Thumbnail sketches of several industrial applications are given. Short reviews of several programs for the Apple, IBM and CP/M-based computers are given. Presentation systems, including one which is capable of limited animation and mixing of video and digital display are discussed in addition to static graph-design systems. A list of vendors is provided.

David Gabel, "Computer Graphics: The Perfect Visual Message", Personal Computing, February, 1983.

This article gives an overview of business presentation graphics (bar charts, pie charts, plots) on personal computers. It surveys input devices (keyboard, light pen, trackball, mouse, digitizer) and output devices (display, plotter, printer). Software is discussed in general terms. An example using PFS Graph is shown and some sample applications

are mentioned. An index of hardware and software vendors accompanies the article.

ORGANIZATIONAL ISSUES

Amy Wohl and Kathleen Carey, "We're Not Sure How Many We Have", Datamation, December, 1982, p. 106

Discussion of the results of a survey of corporate microcomputers which identifies significant problems in the areas of configuration control, communication, software, hardware maintenance, and support.

Robert A. Becker, "The Need for Rigorous Analysis of OA Proposals", Computer Decisions, November, 1982, p. 78

Discusses problems in implementing office automation systems among users who are reluctant to use any kind of automated data processing equipment and those who are overly enthusiastic about the hardware. Also identifies difficulty of cost justifying installation of office automation systems.

B.G.F. Cohen, M.J. Smith, and L.W. Stammerjohn, "Psychosocial factors Contributing to Job Stress of Clerical VDT Operators", AFIPS Office Automation Conference, American Federation of Information Processing Societies, March, 1982, p. 117

Describes the results of a NIOSH study of VDT (i.e. CRT) workers in large organizations. Although the study was apparently (not explicitly stated) for mainframe systems, the results have implications for microcomputer based systems as well. Among the conclusions are that job stress from other factors can be exacerbated by the introduction of computing technology and that clerical workers experienced more stress than managerial workers because the latter had discretion over the use of their systems.

Comptroller General of the United States, Strong Central Management of Office Automation Will Boost Productivity, United States General Accounting Office Report GAO/AFMD-82-54, September, 1982

A study of five office automation installations in Government agency and one corporation. The study pointed out a number of problem areas and cited problems in establishing cost justification and following the progress of the system after installation. The study has implications for major purchases of microcomputers by Federal agencies as well as the installation of microcomputer-based local area networks as well

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This document is an introduction to microcomputers and their uses in the Federal government. Basic concepts in microcomputers are discussed, and their uses by clerical, administrative, professional, and technical Federal personnel are described. The motivations, costs, and risks of microcomputer use are identified, and recommendations for successful implementations are provided. Appendices contain a glossary and annotated bibliography.

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